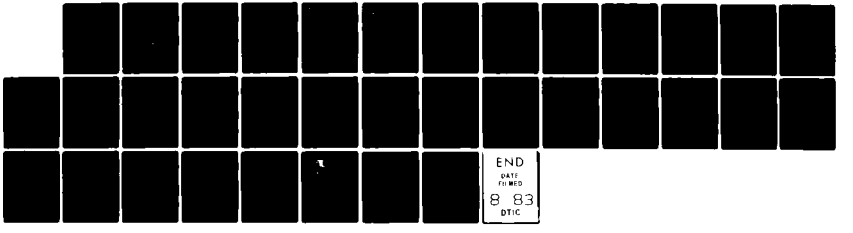
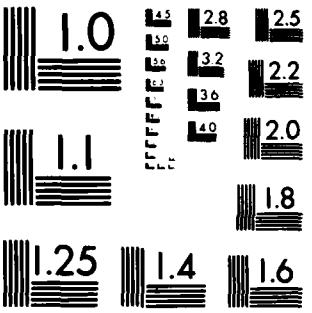
AD-A130 415 EUROPEAN SCIENTIFIC NOTES VOLUME 37 NUMBER 5(U) OFFICE 1/1
OF NAVAL RESEARCH LONDON (ENGLAND) D MOSHER ET AL.
31 MAY 83 ESN-37-5

UNCLASSIFIED F/G 5/2 NL





(12)

OFFICE OF NAVAL RESEARCH
LONDON

EUROPEAN SCIENTIFIC NOTES

ESN 37-5

31 May 1983

Distributed by the
Office of Naval Research Branch Office,
London

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER 37-5	2. GOVT ACCESSION NO. AD-A130415	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) EUROPEAN SCIENTIFIC NOTES		5. TYPE OF REPORT & PERIOD COVERED Monthly May
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) David Mosher and Larry E. Shaffer, editors		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Office of Naval Research, Branch Office London Box 39 FPO NY 09510		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE 31 May 1983
		13. NUMBER OF PAGES 28
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report)
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

APPROVED FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

European Scientific Notes (ESN) is a monthly publication with brief articles on recent developments in European scientific research. The publication is not intended to be part of the scientific literature. The value of ESN articles to Americans is to call attention to current developments in European science and technology and to the institutions and people responsible for these efforts. ESN authors are primarily ONRL staff members. Occasionally articles are prepared by or in cooperation with staff members of the USAF European Office of

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-LF-014-6601

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Aerospace Research and Development or the US Army Research and Standardization Group. Qualified US scientists traveling in Europe may also be invited to author and ESN article.

EUROPEAN SCIENTIFIC NOTES
OFFICE OF NAVAL RESEARCH
LONDON

Edited by David Mosher
Larry E. Shaffer

Vol 37, No. 5 31 May 1983

CHEMISTRY

At the International Conference on the Physics and Chemistry of Conducting Polymers, presentations on chemistry dealt with the synthesis and electrochemistry of polyacetylene and other polymers and with their use in batteries. Some of the polymers have interesting electro-optical properties.

COMPUTER SCIENCES

Robotics research at Laboratoire d'Informatique pour Mecanique et les Sciences de l'Ingenieur (LIMSI) concentrates on robotic recognition of objects, robot control, the LIMSI robot, and a real time robotic language.

ELECTRONICS

New approaches to characterizing semiconductor crystals (even *in situ*) lead to better materials. A new silicon-on-insulator method appears to be free of low angle grain boundaries and economical to grow.

The Univ. of Sheffield--long known for its work in solid state microwave devices--is expanding its research to include solid state electro-optic devices. Fundamental studies directed toward the characterization of semiconductor materials continue.

MATERIAL SCIENCES

This is the second in a series of articles reporting research activities on fiber composite materials in the UK. Research at the Loughborough Univ. of Technology and the Univ. of Bath is highlighted this month.

OPERATIONS RESEARCH

PHYSICS

SPACE SCIENCES

NEWS & NOTES

ESN 37-5 (1983)

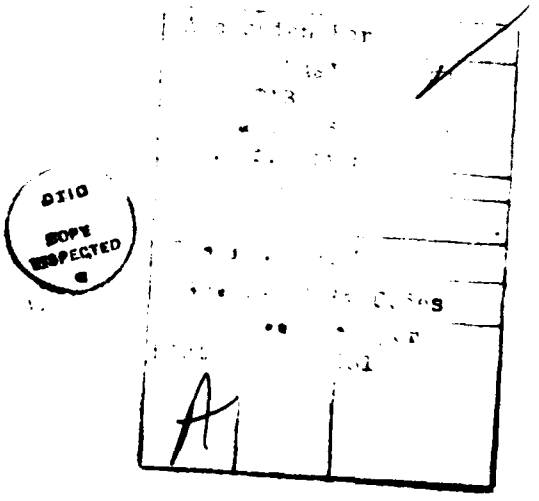
European Scientific Notes is a Class I Periodical prepared and distributed by the Office of Naval Research London in accordance with NAVEXOS-P-35.

F.A. Richards
Chief Scientist

L.B. Sykes
Captain, USN
Commanding Officer

ONRL STAFF

Dr. R.W. Armstrong	Material Sciences
Dr. D.R. Barr	Operations Research
Dr. J.F. Blackburn	Computer Science
Dr. N.A. Bond, Jr.	Psychology
LCDR R.W. Booker	Environmental Systems and Military Oceanography
Dr. R.L. Carovillano	Space Physics
Dr. T.-W. Chou	Material Composites
Dr. D. Mosher	Plasma Physics
Mrs. D.L. Mott	Librarian
LCDR M.D. Schroeder	Undersea Systems
Dr. V.T. Stannett	Polymer Chemistry
CDR J.A. Strada	Aerospace Systems
CDR M.G. Surdyk	Command, Control and Communications
Mr. M.N. Yoder	Electronics



CHEMISTRY

CHEMICAL ASPECTS OF ELECTRICALLY CONDUCTING POLYMERS

The physics and chemistry of conducting polymers were discussed at an international meeting held at Les Arcs, Bourg St. Maurice, France, from 11 through 14 December 1982. The meeting was supported by ONR London, a number of French government agencies, IBM (France), and Compagnie Thomson-CSF (France). Technically, the meeting was dominated by 29 papers and 76 posters on the physics and chemistry of polyacetylene. By far the greatest emphasis of the meeting was on the physics of conducting polymers. However, many participants said that there is a need for new polymers with properties that are better than those of polyacetylene and polypyrrole. This article deals with the chemistry of conducting polymers; some of the discussions about physics and theory are treated elsewhere in this issue.

Polyacetylene

The classical method of synthesizing polyacetylene (PA) films was developed in 1972 by H. Shirakawa (Univ. of Tsukuba, Japan), then at the Tokyo Institute of Technology. He used a Ziegler-Natta catalyst based on triethyl aluminum and titanium tetrabutoxide with acetylene gas directed on the surface of the catalyst solution. In reality, the so-called films displayed a fibrillar-mat-like structure. At low temperatures, all-cis polymer was formed, while higher temperatures gave increasing proportions of trans. The latter is more stable, and the cis is transferred to the trans on a heat treatment.

Many papers and posters discussed the synthesis, the isomerism, and the chemistry and structure of PA. Dr. M. Aldissi (Universite des Sciences et Techniques du Languedoc [USTL], Montpellier) presented some kinetic results based on the Shirakawa method. The experiments were based on the original liquid surface technique. The rate decreased as the thickness of the polymer layer increased. Maxima were exhibited in the rates versus the time of catalyst aging and the Al:Ti ratio. The density of the films was higher on the gas side than on the liquid. The other kinetic results were as expected.

Dr. S.K. Tripathy (GTE Inc., Waltham, MA) discussed how the morphology of the polymer films could be varied by changing the polymerization kinetics. Processibility was improved considerably when PA was blended with a suitable processible polymer, such as cis, 1,4, polybutadiene, or ethylene-propylene rubbers. Blending was best accomplished by growing the PA in the presence of a second polymer. The PA segregated into domains, opening up interesting possibilities for research.

Dr. J.L. Baker (Bell Telephone Laboratories, Murray Hill, NJ) described the preparation of a soluble form of PA by preparing graft copolymers of a soluble polymer and PA. The grafts could be used for studying isolated PA chains in solution, manipulating the morphology, and fabricating devices. Phase separation occurred on film formation with spherical domains. Conductivity has not yet been measured on isolated PA spheres.

Dr. G.E. Wnek (MIT, Cambridge, MA) described the preparation of block and graft polymers containing PA segments. The carbanions present in n-type PA were used to initiate the polymerization of styrene and isoprene; other monomers are under study. In some cases, soluble fractions could be obtained. The electrical properties and morphology are being investigated. Wnek also tried to make block copolymers.

Dr. W.J. Feast (Univ. of Durham, UK) described a two-step synthesis of PA using metathetical ring opening (Figure 1).

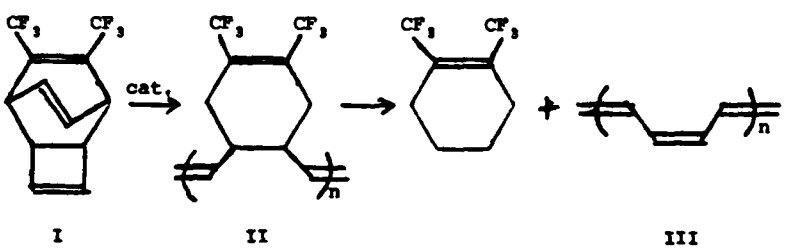


Figure 1. Two-step synthesis of PA.

Polymer II in Figure 1 is soluble and can be fabricated into various forms and converted to PA by heat. The PA is trans, dopes well, and can be made in an essentially nonfibrous film form with low crystallinity. Dr. G. Leising (Technical Univ., Graz) also has prepared PA films using the techniques of Feast. All-trans polymer was obtained with a higher density, greater stability in air, and fewer surface fibrous features than the normal Shirakawa films. Dr. J. Hocker (Bayer A.G., West Germany) described the use of a special Ziegler- Natta catalyst. PA was produced as burrs or short fiber particles that could be processed into various shapes for films, coatings, or mixed component nonwovens. Dr. H. Kuzmany (Univ. of Vienna), in a study coauthored with workers from the Central Research Institute for Chemistry, Budapest, prepared PA under very pure and oxygen-free conditions; spectral analysis showed far fewer imperfections in the resulting polymer.

Other Polymers

Dr. G.B. Street (IBM, San Jose) and Dr. P. Pfluger (IBM, San Jose and Univ. Basel, Switzerland) reviewed the electrochemical synthesis of polypyrrole and derivatives and discussed a variety of physical methods for obtaining structural information. The synthesis of poly (β, β'-dimethylpyrrole) and poly (β, β'-diphenylpyrrole) was described. Poly (β, β'-dimethylpyrrole) is of interest as a semicrystalline polymer whose relatively ordered, planar structure was inferred from x-ray and modeling studies. Electron spectroscopy shows inequivalent nitrogen and carbon atoms in partially oxidized (conducting) polypyrrole.

Papers on polyparaphenylene included a contribution by G. Froyer et al. (Lannion, France). Two methods of synthesis were used, and the properties of the products were compared. The Kovacic synthesis uses $CuCl_2$ oxidation of benzene in the presence of $AlCl_3$, while the Yamamoto method employs a $NiCl_2$-catalyzed Grignard coupling of p-dibromobenzene:

$$\text{Kovacic: } nC_6H_6 + 2nCuCl_2 \xrightarrow{AlCl_3} (C_6H_4)n + 2nHCl + 2nCuAlCl_4$$

$$\text{Yamamoto: } BrC_6H_4MgBr \xrightarrow[bipy]{NiCl_2} Br(C_6H_4)nMgBr + nMgBr_2$$

The Kovacic polyparaphenylene is a brown powder, while the Yamamoto material is yellow. Differences in optical, infrared, and conductivity behavior were observed and correlated with structural and compositional studies. (Yamamoto's material contains 10% Br, and may have a lower molecular weight.)

Dr. B. Tieke (Freiburg, West Germany) prepared thin films (<100 nm) of polyparaphenylene by vigorous stirring of freshly formed polymer in a specially designed reaction vessel. Due to high transparency, the films were ideal for transmission spectroscopic studies. Both p- and n-type doping produced strong absorption changes, with an isosbestic point being observed at 24,000 cm^{-1}.

The structural aspects of conducting polymers were reviewed by G. Wegner (Freiburg, West Germany). He used the known reactions and structures of arenes and arene charge transfer complexes as models for the redox behavior of poly (p-phenylene). Thus the reaction of arenes to form crystalline dimeric radical cations of known structure was used as a model to understand the "doping" and structure of partially oxidized poly(p-phenylene).

One of the most interesting "new materials" papers was a poster by S.T. Wellinghoff et al. (Univ. of Minnesota, and Honeywell, Minneapolis, MN). Poly (N-methyl 3,3 carbazolyl) (PC-I) was prepared via a Grignard route. PC-I was soluble in a number of donor solvents, and thin films could be cast and doped with I_2 and Br_2. Conductivities as high as 1 ohm^{-1} cm^{-1} were observed, and doped materials were stable to ambient air for at least 1 month. Thus the processibility and stability of PC-1 conducting materials is remarkable.

Poly (p-azophenylene), $-(C_6H_4N{=}N-)$ is another new nitrogen-containing polymer that can be prepared by CuCl-catalyzed oxidation of p-diaminobenzene (F. Barbarin et al., Aubiere Univ., Clermont, France). Doping with I_2 effects a 10^5 increase in conductivity to only 5×10^{-5} ohm^{-1} cm^{-1}, demonstrating that the presence of nitrogen does not guarantee high conductivity.

Prof. T.J. Marks and Dr. T. Inabe (Northwestern Univ., Evanston, IL) reported on unusual bridge-stacked phthalocyanine (Pc) polymers. Remarkable features include solubility without decomposition in strong acid solvents, high thermal stability (>200°C in air), and high conductivity of doped materials (to 5 ohm^{-1} cm^{-1}). The structure of the conducting, partially oxidized $(PcMO)_nI_x$, M = Si, Ge, Sn, was

inferred from x-ray powder data and the crystal structures of model compounds.

Dr. M. Hanack (Univ. Tübingen, Germany) described a number of ligand-bridged macrocyclic complexes, e.g., pyrazine-bridged iron phthalocyanine. Although such complexes are generally intractable powders, they have an interesting property--relatively high conductivity (to 10^{-5} ohm^{-1} cm^{-1}), which can be increased to 10^{-1} ohm^{-1} cm^{-1} with doping. Remarkably, the use of cyanide as a bridging group in $[PcFeCN]_n$ and $[PcCoCN]_n$ raises the conductivity to 10^{-2} ohm^{-1} cm^{-1} without doping.

Electrochemistry

The surprising stability of p-doped polyacetylene to water was outlined by Prof. A.G. MacDiarmid (Univ. of Pennsylvania, Philadelphia). Chemical p-doping was carried out in $HClO_4$, H_2SO_4, and HF to give a variety of conducting compositions that did not contain oxygen. As measured by conductivity, doping in strong acids seems rapid (30 minutes), but this is a surface effect, and compositional equilibrium is reached only after 24 hours. Several battery systems using $(CH)_x$ electrodes were described. Apparently, n-doped polyacetylene has better stability with regard to reversibility than does p-doped $(CH)_x$. Cells based on $Li/(CH)_x$ were stable for many months, showing no measurable degradation.

Dr. M. Armand (Domaine Univ., St. Martin, France) presented an electrochemist's view of conducting polymer batteries. The compositional aspects of electrochemical doping were treated as a kind of intercalation. The stringent requirements for reversibility and intolerance of parasitic reactions were stressed. Favorable features of $(CH)_x$ as a battery electrode include a fibrillar morphology that allows rapid ion-electron exchange and redox reactions to occur at less extreme potentials than graphite. Disadvantages include apparent side reactions of p-doped $(CH)_x$ with solvent, compositional staging, which can change the potential as a function of percent oxidation, and redox reactions of solvents. Despite such difficulties, the prospects for using conducting polymers in batteries appear favorable.

Prof. F. Beniere provided an intriguing demonstration of conducting polymer batteries by using solid state $(CH)_x$ batteries in a watch he wore throughout the conference, in a hand-held electronic game he passed out during his presentation, and in a timer he used for his talk. The batteries--consisting of an n-doped $(CH)_x$ or metal anode, a solid electrolyte, and a p-doped $(CH)_x$ cathode--put out a maximum of 200 μW and displayed stable voltages over a wide temperature range (-20 to +40°C). Dr. M. Gazard (Thomson-CSF, Domaine de Carbeville, Orsay, France) presented results on the electrochromic behavior of thin films of conducting polymers. Such films were prepared by electropolymerization and their electro-optic properties assessed. Optimal behavior was observed for polypyrrole, which changes from brown to yellow between 0 and 0.7 V (versus saturated calomel electrode), with a switching time of 200 ms and minimum lifetime of 10^4 cycles.

More than 300 attended the meeting, including about 90 from France and 70 from the US; other attendees were from all the western European countries, Japan, USSR, Israel, Poland, Hungary, and elsewhere. Fifty-nine papers and 119 posters were presented, of which the largest numbers (27 papers and 41 posters) were from the US. The proceedings of the conference will be published in the "Colloquium" section of the *Journal de Physique*.

K.J. Wynne
ONR, Arlington, VA

V.T. Stannett

COMPUTER SCIENCES

ROBOTICS RESEARCH AT ORSAY, FRANCE

The Laboratoire d'Informatique pour Mecanique et les Sciences de l'Ingenieur (LIMSI) at Orsay, France, is one of the important laboratories of the Centre National de la Recherche Scientifique (CNRS). There are three research groups in LIMSI: modelling and numerical simulation, spoken communication, and robotics. This article describes robotics projects dealing with recognition of objects, control, the LIMSI robot, and real time robotic language.

Robotic Recognition

Research on robotic recognition covers:

- Analysis and filtering of visual information: the image coming from an optical sensor is processed in real time

by a specialized processor obtaining an image of contours from a camera developed at the laboratory.

- Encoding of the image: the encoding principle used is an encoding by zones following the direction of scanning.
- Three-dimensional knowledge: the three-dimensional characteristics of an object or scene are determined from two images of the same scene taken from two different points of view (parallax).
- Representation of the characteristic elements of the analyzed scene: the discriminating criteria are those generally used in robotic applications--area, perimeter, area-perimeter ratio, center of gravity, moments of inertia, principal axes, and relative position in the space.
- Recognition of objects: from characteristic elements, the object is recognized by comparison with objects contained in a reference table. Auto-adaptive and programmable criteria ensure automatic recognition. The research should help produce a specialized image processor to serve the sensor used.

The programs for analysis and coding of images are operational on the IBM 370/168 computer and the Texas Instruments 990-4 16-bit minicomputer. The first sections of the image processor are near completion. The logical extraction of the three-dimensional image from two images is being simulated and will later be adapted to real time. The problem of real time control of the experimental optical sensor is treated in the frame of applications of the robot developed by the group. The control of movements must be realized in a closed loop and generated from data furnished by the computer associated with image processing.

Robot Control

The purpose of the research is to simulate kinematic and dynamic control of a system with six degrees of freedom and to construct a control unit adapted to the system.

Geometric Model. The problem of control in the geometric model requires the transformation of coordinate frames. The transformation between two coordinate systems is a combination of a translation and a rotation in which a matrix operator for the translation and rotation transforms a vector representing the coordinate set. In the more general case of N translations involved in determining the end effector (gripper or other operational end element) position and orientation in the coordinate frame of the manipulator base, the product of N matrix transformations must be performed. After forming the product matrix, the direct method of solution requires equating this product times the vector of the coordinates of the end effector in one system, to the vector of unknowns representing the coordinates of the end effector in the desired system and then calculating the unknown vector elements.

Kinematic Model. In a kinematic model, account is taken of motion, which may include velocity and acceleration. The end effector position and orientation, $\underline{X}$, is a function of the manipulator link angles, $\underline{\theta}$:

$$\underline{X} = \underline{F}(\underline{\theta}) \quad .$$

Differentiating with respect to $\underline{\theta}$,

$$\frac{\partial \underline{X}}{\partial \underline{\theta}} = \frac{\partial \underline{F}(\underline{\theta})}{\partial \underline{\theta}} = \underline{J} \text{ (the Jacobian matrix).}$$

The finite difference form can be written

$$\Delta \underline{X} = \underline{J} \cdot \Delta \underline{\theta}$$

so that $\Delta\theta$ can be found in terms of $\Delta \underline{X}$ using

$$\Delta \underline{\theta} = (\underline{J})^{-1} \cdot \Delta \underline{X} \quad .$$

The inverse of the Jacobian must be computed in order to solve for $\Delta\underline{\theta}$. Two methods of inversion have been proposed which take motion into account. For example, the method of principal variables imposes a limitation on movements on a certain number of articular variables. Another approach is to minimize a certain quadratic function over the kinetic and potential energy of the robot.

Dynamic Model. The study of dynamic models takes into account forces of inertia and coupling that appear when the robot operates at high speed. Models obtained for structures with more than three degrees of freedom are complex and contain many terms that present problems in real-time control. The elaboration of a control law using prediction of dynamic couplings seems to improve the precision of an actual control.

The three control models have been simulated for the laboratory robot; a coordinator of movements has been developed. A logical, low-level control unit has been simulated to verify the validity of the models. The unit includes the elementary functions: going from one point to another, describing a circular or rectangular trajectory, and

performing rotations around one or more axes of the effector. Work is under way on the logical interface with the robot.

The LIMSI Robot

A robot with six degrees of freedom is being developed at LIMSI to support robotic research; the machine will allow researchers to test algorithms of command and to control complex robotic tasks, such as simulation of assembly, inspection, and movement.

The robot is to have electric actuators, a work space of 0.5 m^3 with the possibility of extension, high precision, simplified control, and a maximum load compatible with precision and speed.

The structure and performance of the robot should permit study of kinematic and dynamic control as a function of the various loads, and simulation of assembly, automatic inspection, gripping, and prepositioning. The robot will be used as a support for orientable sensors when a mobile turret is added, and as a tool of manipulation after extension to six degrees of freedom.

The robot has the following characteristics:

1. Movement of 1 m in the X and Y directions; 0.5 m in the Z direction.
2. Minimum steps (or resolution) of 0.1 mm in X and Y, 1 cm in Z.
3. Load of 20 kg.
4. Maximum speed of movement is 5,000 steps per second (50 cm/s) in X and Y and 5 cm/s in Z.
5. Indication of integral position (i.e., coordinate values) at each movement.
6. Indication of origin.
7. Possibility of manual control for movement, alarm, and emergency stop.
8. Stepping motors with accounting of actual steps and control by microstep (0.1 step).

The robot can be controlled numerically by various processors through an interface connected to a bus connected to the processor interfaces.

The robot was designed at LIMSI, and all the electronics and part of the mechanics were made there.

Analysis of the Immediate Environment of a Robot

The purpose of this effort is to design a system to determine the distance to and the dimensions of an object near the grippers. The research is limited to devising a modular optical and preprocessing system controlled by a microprocessor. The system includes a stereoscopic apparatus for analyzing images and determining distances. The device provides the information needed to determine the size and shape of an object. There is also a unit for closed loop preprocessing to assure automatic adaptation of the clarity and convergence of the optical system. The unit allows preprocessing to be controlled from an external processor that (1) computes distances using the maximum gradient from the optical image and the convergence distance relation, (2) determines the color of the points analyzed using the red, green, blue base, and (3) estimates the shape of the object by scanning.

The performance of the optoelectronic apparatus is being evaluated; researchers are checking the uniformity of gray levels, the spectral sensitivity, and the possibility of programming the spatial definition.

Real Time Robotic Language

The purpose of this research is to develop an interpreter for a high level language that supports a logical structure and assures real-time command and control of a complex robotic system. The interpreter must: load and dynamically activate ordered modules in a library and administer them, synchronize among them and with the environment a hierarchical group of processes functioning in parallel, manage interactively the interfaces for the various languages used in robotics and artificial intelligence, and use the processors and memory as effectively as possible.

Each stage of the research aims to decrease the execution time. The work includes preliminary studies of: (1) formal grammars to define a general syntax for the language that is rapidly analyzable, (2) formal data structures flexible enough to accept various robotic languages, (3) synchronization methods between processes and definition of primitives (basic language elements) compatible with a modular language, and (4) a hierarchical library structure optimizing the management of secondary storage.

The studies must allow various programs to be written in PASCAL, a system sufficiently flexible and general to be easily modified. The programs will include a pre-interpreter composed of lexical and syntactic analyzers associated with a generator of primitives, an emulator of the primitives, and a monitor assuring the loading and activation of the modules, the synchronization of the process, and the management of the main memory. A system of

recovery from errors followed by dynamic execution will be included in all programs.

J.F. Blackburn

ELECTRONICS

MICROSCOPY OF SEMICONDUCTING MATERIALS

As a class, semiconducting materials have been the subject of more studies by more scientists than any other group of materials during the past two decades. Most of the semiconducting materials in use are single crystalline in composition, so they lend themselves to a better understanding of structure than do the more complex heterogeneous materials. Even so, a vast amount of knowledge regarding semiconductor properties currently eluding our grasp is essential to improving device performance, reproducibility, and reliability.

With such a background, the Third Oxford Conference on the Microscopy of Semiconducting Materials was held from 21 through 23 March 1983. Major emphasis was placed on determining the influence of various processing techniques on the resulting electrical and structural properties of the semiconductors. Topics included high resolution electron microscopy, dislocations, scanning electron microscopy (SEM), electron beam induced conductivity, cathodoluminescence (CL), and x-ray microscopy. Processing of semiconductor materials by transient annealing received considerable attention, as did assessment of semiconductor devices by SEM and transmission electron microscopy (TEM). Unconventional microscopy approaches were predominantly acoustic. Over 80 papers were presented to an audience exceeding 200; 70% of the registrants were British.

Transient Annealing

Although significant advances in photovoltaics have been achieved during the past few years, a low cost process leading to high efficiency solar cells has not been developed. T.J. Cumberbatch and colleagues at Thorn EMI Central Research Laboratories have joined with G.J. Russell and colleagues at the Univ. of Durham to develop CdS-based heterojunction photovoltaic cells by a method that provides a basis for production. The process begins with the electrophoresis of CdS on glass or stainless steel. The as-deposited material consists of small cubic sphalerite crystals of 20- to 40-nm diameter with a resistivity greater than 10^6 Ω-cm and consequently of little use as deposited. To become useful, the crystallites must be transformed by annealing into large grain hexagonal crystals with c-axes normal to the substrate. Although many techniques were used to transform the crystals and increase their conductivity, the processes were generally expensive or did not result in grown crystals of the required sizes. Techniques used to determine the degree of phase change transformation, grain growth, and electrical properties included transmission electron microscopy, high energy electron diffraction, x-ray diffraction, Auger spectroscopy, and CL. Of these, the intensity and spectral shape of the CL signal has been most effective in rapidly assessing the state of the material after each of several annealing procedures.

A major problem was the resulting mixture of crystal structures obtained by conventional thermal annealing, electron beam annealing, and moving graphite strip annealing. When transient annealing techniques are used, the maximum temperature attained and the temperature distribution throughout the layer thickness are primarily functions of power level (i.e., rate of temperature rise) and rate of intergranular heat transfer. The relationship between the two is strongly nonlinear and imposes rigid controls over power, duty cycle, and sweep rate of the annealing laser. To gain control over the procedures optimizing the process, a dye laser with 3-μs pulses is used to deposit 3.5 J/cm² at a duty cycle and sweep rate dependent on surface reflectivity as measured by a HeNe laser monitor. A typical procedure first brings the material to 400°C and then holds it at 200°C for a longer period. Cu_xS heterojunction contacts are applied by a solution dipping process followed by laser annealing.

Although alloyed AuGeNi ohmic contacts on GaAs semiconductor devices are now used almost universally, it has been difficult to reproduce them on InP. P.J. Topham and colleagues at Plessey Research Ltd. have investigated the use of Q-switched ruby lasers to see whether the ohmic contact process could be controlled adequately by transient processing techniques. Using Auger spectroscopy, electron microprobe analysis, and Rutherford backscattering data correlated with contact resistivity measurements, they have determined the critical conditions for reproducibility. First, energy density must exceed 0.38 J/cm² to ensure that the gold dissolves.

Second and equally important is that InP disassociates at energy densities greater than 0.5 J/cm². The resulting free P combines with the Ni to form NiP, which acts as a barrier preventing required Au diffusion. Thus the laser energy "window" to ensure good and reproducible results is 0.4 to 0.5 J/cm². Using this approach, Topham can obtain specific contact resistivities of 8.1×10^{-6} Ω-cm².

Polycrystalline silicon films are used as gate electrodes and for short interconnections within metal oxide semiconductor integrated circuits. Even when heavily doped, however, the films' high resistivity limits device speed. M.N. Kozicki and J.M. Robertson of the Univ. of Edinburgh have investigated the implantation of Co and Cr ions into polysilicon at doses of 5×10^{17}/cm² and at depths accruing from ion energies up to 500 keV. The implants were annealed by both conventional furnaces and by scanned electron beams. The former produced metal precipitation, whereas the latter resulted in smooth surfaces. The electron beam parameters were 500-μm diameter, 7.5 W, 10 keV, and 10 seconds duration. Upon annealing, the Co-implanted material's resistivity was reduced to 0.9 Ω/□, while the Cr-implanted material became more resistive. The Co-implanted material exhibited good high-temperature stability and had no adverse reduction effects on SiO_2. Japanese work in the field has shown that ion beam "mixing" (annealing) is also superior to furnace annealing.

Dislocations

Y.A. Ossipyan of the USSR Academy of Sciences presented a paper entitled "Motion of Charged Dislocations in $A^{II}B^{VI}$ Semiconductors." Ossipyan presented evidence of a photoplastic effect in II-VI semiconductors (e.g., CdSe, ZnO). During periods of several minutes, plastic deformations cause moving dislocation fronts that couple to the electronic subsystem of the crystal. Conversely, the magnitude of the electric charge associated with a moving dislocation plays an important role in plastic deformation of semiconductors. Ossipyan has determined the absolute values of the charges and their dependence on temperature, plastic deforming rate, and illumination parameters. The high value of dislocation-generated electric charges has been shown to follow a model based on nonequilibrium filling of electron dislocation levels at the moving dislocation wavefront. Ossipyan is convinced that the effect is not piezoelectric. The physical phenomenon may have application to the detection of signals whose frequency is less than 1 Hz.

Sir Peter Hirsch (Director of the UK Atomic Energy Commission and until recently head of the Department of Metallurgy and Science of Materials, Oxford Univ.) presented evidence of electrically active impurity dopants affecting the mechanical properties of materials. For example, p-type impurities harden germanium, while n-type dopants soften it. Recrystallization kinetics is also affected by electrically active impurity dopants. The dislocation velocity is proportional to the concentration of the kinks and a function of the stress created by the impurities. Direct *in situ* observations of dislocation movement are now possible with high voltage electron microscopy (see "Metallurgy and Materials at Oxford," *ESN* 37-3:105 [1983]). The origin of these movements is thought to lie in the occurrence of deep electron energy levels associated with charged states of defects. The energy levels do not necessarily relate to static energy levels, but are influenced by dislocation velocity and other dynamic factors. Potential applications include the toughening of diamond, silicon carbide, and other brittle materials.

Silicon Characterization

G. Fontaine and colleagues (Claude Bernard Univ., Lyon) have developed and refined an extremely powerful technique for characterizing silicon. Using a field emission gun of a scanning electron microscope, they electron-bombard a semiconductor crystal mounted on a goniometer, thus permitting precise orientation to obtain selected-area channelling patterns. The backscattered electrons are then detected in a high-pass energy filter-detector. Resolution of 100 angstroms is now obtained; mechanical vibration limits the present apparatus. Among the crystalline characterizations possible are dislocations (as deep as the junction interface), stacking faults, precipitates, grain boundary dislocations, microtwins (e.g., in silicon on sapphire), the effect of electron beam annealing, extrinsic stacking faults during oxidation, and electron beam induced conductivity in junction devices.

The paper that may provide more potential for exploitation than any other at the conference was by H. Baumgart of Philips, F. Phillipp of the Max-Planck Institute, and C.K. Celler of Bell Telephone Labs. It addressed the defect structure of epitaxial films grown on porous silicon. Although

porous silicon was discovered 30 years ago during electropolishing attempts, it has not been commercially exploited. A current use is to provide a silicon medium that can be oxidized beneath the surface without creating stress within the material and without destroying the silicon crystalline pattern on the surface. The electrolytic technique uses a silicon wafer as an anode through which a current density of 50 mA/cm² is passed (for 10 minutes) via an HF ionic solution to a cathode. This creates a 10-μm-deep porous silicon layer of one-half the original density upon which a nonporous epitaxial silicon layer is grown. The structure is baked at 250°C for 1 hour to remove any HF. Previous attempts at epitaxial growth destroyed the porous region, but low temperature epitaxial procedures have eliminated that problem. In contrast to previous silicon-on-amorphous-insulator materials, the resulting material is free of low angle grain boundaries. The underlying porous silicon has an extraordinarily high chemical reactivity deriving from its high surface-to-volume ratio. After parallel channels have been opened in the epitaxial nonporous silicon layer, the structure is oxidized for 15 minutes at 450°C to permit oxygen to permeate the underlying porous structure, followed by higher temperatures to grow the SiO_2. The technique permits total device isolation by subsequent vertical oxidation. High voltage electron microscopy and scanning electron microscopy were used to evaluate the structures. The continuous underlying oxide layer not only improves device speed, but it also significantly improves device resistance to x-rays and gamma rays. The process is significantly cheaper than the silicon-on-sapphire technique and provides an active silicon layer of higher quality with virtually no constraints on thickness.

M. Beale and G. Booker of Oxford Univ. have implanted both [100] and [111] silicon with BF_2 ions in large concentrations (e.g., 10^{14} to 10^{16}/cm²). The [100] slices could be regrown virtually defect-free, while the [111] slices were twinned at BF_2 fluences exceeding 10^{14}/cm². Analysis showed that 95% of the fluorine was lost during [100] recrystallization, while 50% of it remained during [111] recrystallization attempts.

M.N. Yoder

THE SPECTRUM BROADENS AT SHEFFIELD

The Univ. of Sheffield's Department of Electronic and Electrical Engineering has been designated the UK Science and Engineering Research Council's (SERC) lead school for the epitaxial growth of III-V semiconductor films. Certain III-V compound semiconductors (e.g., GaAs and InP) exhibit electron velocities and electron mobilities considerably in excess of those of silicon; in addition, they can emit light.

During my recent visit to Sheffield, Prof. Peter N. Robson discussed the semiconductor work at the university. Robson, a Fellow of both the Institution of Electrical Engineers (UK) and the Institute of Electrical and Electronic Engineers, was recently reappointed Deputy Dean of the Sheffield Faculty of Engineering. Internationally known for his pioneering work in transferred electron devices, he organized the Eighth European Specialist Workshop on Active Microwave Semiconductor Devices.

Facilities

The SERC Central Facility for III-V semiconductors is operated by the school and has a charter to custom grow epitaxial layers for other UK university departments and to assist them in device fabrication. The Central Facility has available a clean room, several liquid phase epitaxial (LPE) reactors (or kits as they are known in Britain), a metallorganic chemical vapor-phase deposition (MOCVD) reactor capable of depositing GaInAsP material of any mole fraction, a scanning electron microscope with electron beam induced conductivity and cathodoluminescence contrast attachments, energy dispersive x-ray spectrometer, a mask-making facility, lithographic and photographic facilities, and vacuum evaporators. A recently awarded SERC quadrennial grant of £1 million will provide a second large clean room in 1983, a new fabrication facility, and a new Vacuum Generators molecular beam epitaxy (MBE) reactor. Microwave, millimeter wave, and video test facilities are available to characterize devices.

$(In_{1-x}Ga_x)(As_yP_{1-y})$ Charge Carrier Transport

In this quaternary system, any mole fraction in which $y = 2.2x$ will result in a crystal whose lattice constant equals that of InP. Such versatility of composition and resulting spectrum of electronic properties provide the basis for many device concepts, including high speed heterojunction bipolar transistors and logic gates, long wavelength injection lasers, transferred electron oscillators for microwave and millimeter

wave sources, field effect transistors, photodiodes, photo transistors, and electro-optic waveguides and couplers. Improving the performance of any of these devices requires "bandgap engineering" and a knowledge of the charge carrier transport properties of the material.

In III-V direct gap semiconductors, the charge carrier transport properties are not well defined on the basis of Hall-effect mobility measurements alone. Previous attempts to measure electron drift velocity by the pulsed Ryder method have provided static rather than dynamic (overshoot) readings; previous microwave time-of-flight measurements have given only relative velocities and require at least one point of normalization. The Sheffield group has recently developed a time-of-flight charge carrier measurement technique using variable frequency microwave excitation. Deflection modulation is imposed on the impinging electron beam by a traveling wave helical structure. The versatility obtained by the frequency, beam energy, and semiconductor bias variability allows one to measure the charge carrier drift velocities absolutely over a wide range of values.

The inherent accuracy of the measurement technique has led to new findings. For electric field strengths below 10 kV/cm, deep acceptor traps produced anomalies in the electron velocities.

There can be larger energy separation between the central (Γ) and the subsidiary (L) conduction band minima in the ternary and quaternary alloys than in the constituent binary semiconductors. Therefore, electrons can gain more energy in the Γ region before transferring to the L region, and significant increases in charge carrier velocity are expected. Experiments verify some but not all of the expected velocity increases. As the constituent elements in alloy semiconductors do not sit on their respective group III or group V lattice sites in a regular manner (as do the anions and cations of a binary material), drifting electrons suffer more scattering, known as alloy scattering. Prof. J. Marsh reasons that a random fluctuation in the alloy composition arising from a binomial distribution of In and Ga atoms on the cation lattice sites will give rise to cluster sizes of about 1,000 atom pairs. A 2% fluctuation in distribution over such a cluster provides 10-meV conduction band steps. Using these steps in Monte Carlo simulation of electron transport in GaInAs material provides a solution consistent with both low field electron mobility data and electron velocity data at high electric fields. The calculations indicate that an In (53%) Ga (47%) alloy (i.e., a ratio whose atomic lattice constant equals that of InP) is most advantageous for transistors and transferred electron devices. With such high velocity material, Marsh hopes to demonstrate millimeter wave oscillators operating in the fundamental mode at frequencies exceeding 100 GHz.

Ionization Coefficients in Alloy Semiconductors

Modulation doped structures, multiple heterojunction quantum well devices, and a general class of two-dimensional electron gas devices are becoming of greater interest, thus knowledge of breakdown voltages as a function of alloy ratio becomes increasingly important for maximum operating efficiencies. Knowledge of the breakdown voltages over the range of alloy compositions possible requires both hole and electron ionization coefficient data at corresponding compositional ratios. The data do not exist now.

Robson and his students have devised a simple but exacting technique for measuring ionization coefficients. A p^+n diode is fabricated, and a doughnut-shaped ohmic contact is made to the top p^+ surface. The central region of the bottom n surface is thinned to 10 μm by a 2% bromine methanol etch, and an ohmic contact is configured around the thinned region. A chopped 635-nm laser beam is impinged first on the top and then on the bottom of the diode as the bias is varied and diode current is monitored. The laser generates electron-hole pairs first in the p+ region and then in the n region, creating the majority and minority carriers necessary to initiate electron ionization and hole ionization. From a knowledge of the doping densities within the diode, observed breakdown voltages are used to derive the respective β and α ionization coefficients as functions of electric field strength and temperature. Initial results have been limited to InP where β exceeds α by a factor of 2.2 at 5×10^5 V/cm, but the two are equal at 8×10^5 V/cm. Although the ionization coefficients exceed those obtained by other workers, the Sheffield technique is thought to eliminate problems associated with electric field distortion near mesa edges. Diodes will soon be made of various alloy semiconductors and subjected to similar measurement procedures.

Heterojunction Bipolar Transistors

In their emitter regions, conventional bipolar transistors require impurity doping concentrations 50 to 100 times those of the base region. Thus, majority carriers in the base region are negligible and are not appreciably injected into the emitter region to destroy transistor gain. The disadvantage is that the base impurity doping must be limited, causing added resistance in the base region. The resistance (R) adversely affects transistor switching speed by creating large time constants. Although resistance can be reduced by thickening the base region, the minority carrier transit time and junction capacitance (C) increase so that switching speed suffers. Using an emitter whose bandgap is greater than that of the base permits doping of the base region to degeneracy without reducing transistor gain. This process works because forward emitter base bias removes the barrier to minority carrier injection to the base but retains a small potential barrier against base-to-emitter injection. Lattice matched III-V alloy semiconductor junctions provide the obvious approach to a high speed bipolar heterojunction transistor. Having obtained funding from both SERC and British Telecom, the Sheffield group is embarking on a heterojunction transistor merged logic program destined to provide very high speed integrated circuits at very large scale integration density. Epitaxial layers and junctions for the logic devices will be grown by both MOCVD and MBE.

Electro-optics

The deposition of a metal film on the polished surface of a III-V semiconductor induces in the semiconductor a strain that alters the optical index of refraction. The strain discontinuity at the edge of the metal film provides an optical waveguide supporting one transverse electric (TE) and one transverse magnetic (TM) mode of propagation. Prof. T.M. Benson, the department head, and colleagues have found that if two such waveguides are placed near each other, the optical signal in one waveguide will couple to that in the other in a manner analogous to that of couplers designed for the radio frequency spectrum. The confinement effect previously had been thought to derive primarily from refractive index changes induced by the electro-optic (Pöckels) effect. When guiding structures were placed along various crystallographic axes and on several planes of GaAs crystal, however, it was found that the strain-induced changes of refractive index were at least 10 times the electro-optic-induced changes. Using this knowledge, one can choose more efficient crystal orientations, depending on the effect to be exploited in device design. The application of a reverse bias to the Schottky diode created by the guiding metal-semiconductor interface causes an index of refraction change within the optical waveguide and thus alters the propagation velocity of a TE mode signal. If adjacent guides receive differing bias, then synchronism between the two guides is destroyed and coupling no longer occurs. Thus, an optical switch is possible; indeed, switching has been demonstrated. Crossover efficiencies of up to 90% have been obtained with associated isolation (in the crossed-over condition) of 15 dB.

For several years, members of the Sheffield group have studied optical guiding mechanisms based on the above waveguide effects and have been pioneers in the field. Recently, nonlinear behavior in waveguides has been investigated--behavior deriving from the intensity dependence of the refractive index. Because this intensity dependence could be used as the basis for optical logic devices, there is great interest in identifying the responsible mechanisms. Sheffield has two projects to investigate how optical nonlinearities affect the performance of components using the strain-induced waveguiding described above. Both theoretical and experimental aspects are under investigation. Transmission line models are being developed using experimental data derived from variations in propagation constant with optical signal intensity in cooled GaAs photo-elastic waveguides at optical frequencies near the band edge. A new laboratory is being established for the work.

M.N. Yoder

MATERIAL SCIENCES

FIBER COMPOSITE MATERIALS IN THE UK: LOUGHBOROUGH AND BATH

This is the second in a series of articles reporting research on fiber composite materials in the UK. Last month, work at the Univ. of Surrey and Cambridge was highlighted. This month, research at the Loughborough Univ. of Technology and the Univ. of Bath is featured.

Loughborough Univ. of Technology

Extensive research in metal matrix composites is being done in the Department of Engineering Production at the Loughborough Univ. of Technology. The department has over 220 undergraduates and 50 postgraduate students, and there is a substantial, growing research program. The department is unique in British universities in that it has a large purpose-built manufacturing facility called the Center for Industrial Studies. The center provides industrial training for undergraduates who may wish to undertake professional, practical training on campus. The department has an impressive range of laboratories for machine tools, production automation, control engineering, micro-electronics, materials deformation and testing, metal casting, welding, and computing. The effort in metal matrix composites is led by Dr. A.A. Das, and the emphasis has been on composite fabrication. Das has been active in metal matrix composite work for many years. He is now pursuing research on composites fabricated by three methods, all related to squeeze casting at the final stage of fabrication.

Squeeze casting is the term used to describe the press-working of liquid metal into finished shapes. Solidification occurs under high pressure, which is several orders of magnitude greater than the melt pressure developed in conventional foundry practice. As in other methods of casting, the mechanical properties of squeeze-cast products are to a large extent controlled by the structure and morphology derived during solidification. Undercooling below the equilibrium solidification temperature and a rapid rate of heat extraction generally ensure extensive nucleation and a fine equiaxed gain structure in castings.

In squeeze casting, the requirements of both rapid heat extraction and undercooling can be met. The usual phase equilibrium diagram of an alloy neglects the pressure variable and depicts the conditions obtaining at a constant pressure of 1 atmosphere. Pressure applied by the punch or upper die during squeeze casting can amount to a few thousand atmospheres. For alloys that contract on freezing, the high pressure produces an increase in the freezing temperature that can be calculated from the Clausius-Clapeyron equation. For Al-base alloys (except high-silicon-containing alloys, which do not show much contraction), the freezing temperature may increase by 10 to 25°C. If pressure is applied when the molten metal is at a temperature only a few degrees above the liquidus, undercooling in effect occurs throughout the liquid metal mass, although the actual temperature may not have fallen below the equilibrium (1 atmosphere) freezing temperature. The process, along with a high rate of heat removal, causes the undercooled melt to solidify rapidly. Because the solidifying metal is forced against the die by the pressure applied, air gaps do not readily develop between the casting surface and the die wall; heat is transferred to the die primarily by conduction. It has been shown that heat transfer during the solidification of squeeze casting is much more effective than that in gravity die casting. The combination of undercooling with high rates of heat transfer will ensure a fine-grained equiaxed structure (see Das).

At Loughborough, the squeeze casting technique is being used to produce metal matrix composites with "Safill" alumina fibers 1-mm long or Nicalon silicon carbide fibers 3-mm long. Researchers first separate the short fibers into small clusters by "combing" them through a pair of brushes; then the fibers are preheated at 900°C for 2 hours to remove absorbed gases and debris. The matrix material is an alloy of Al + 4% Cu. It is heated to 800°C and degassed by N_2 gas for 2 to 3 minutes, then a rod is used to stir the material with a circular motion at 600 Hz. The stirring creates a vortex in the molten metal and tends to disperse the short fibers evenly when they are poured into a crucible. During the mixing, N_2 gas is used to protect the surfaces of molten metal and fibers. The die for squeeze casting is preheated to 250°C. After the die cavity is filled with the mixture of metal and fiber, the punch is brought into contact with the molten metal. The pressure applied is about 85 MPa. This technique has produced high-quality composites with 10% by weight Nicalon and Safill fibers. Now Das and coworkers intend to use commercial alloys as a matrix for improved high temperature properties.

The second technique of metal matrix composite fabrication at Loughborough uses a combination of powder metallurgy and squeeze casting to incorporate silicon carbide whiskers into metals. The merit of the technique is that the silicon carbide whiskers can be dispersed randomly into an aluminum alloy melt before squeeze casting. The matrix material used is LMII, a copper bearing (4 to 5% Cu) commercial casting alloy that has excellent wetting charac-

teristics with SiC without any apparent degradation of the whiskers. SiC whiskers produced by Metals and Methods Ltd. and Silag Inc. have been used. Simple stirring disperses the individual whiskers in water and separates them from the as-grown mass. However, to keep the whiskers separated when the dispersion is filtered and dried, researchers at Loughborough chose to co-disperse the whiskers with aluminum powder in a mixture of isopropyl alcohol and water. The dried, filtered mass is then pressed into small briquettes, which are degassed in vacuum at about 450°C. The briquettes are then immersed in the melt to incorporate the fiber into the molten matrix. To ensure adequate wetting of the SiC whiskers, the briquettes are held below the surface of the "clean" melt for at least 25 minutes at a melt temperature between 750 and 800°C. The whiskers are wet satisfactorily by the diffusion of copper atoms to the interface between the whisker and alloy. Once wet, the whiskers remain suspended in the melt and do not settle. After the melt has been mixed mechanically, it is squeeze cast.

The third technique of metal matrix composite fabrication at Loughborough is based on compocasting, an application of rheocasting. In rheocasting, metal alloys are vigorously agitated during solidification, and the solid that forms has a special nondendritic structure. Partially solidified metals with such structure behave as highly fluid slurries with solid fractions as high as 60%. The metals can be formed by conventional casting, forging, or pressing processes. In the compocasting process, particulate or fibrous metals are added to the semisolid metal slurry to produce composite materials. The advantage of this casting process for composites is that the nonwetting, uncoated particles or fibers can be dispersed when stirred into the partially solidified slurry of the alloy. The particles are entrapped and prevented from settling or agglomerating because the alloy is already partially solid. With continued mixing, certain particles may interact with the liquid matrix, thus promoting bonding. So far, the work at Loughborough has incorporated graphite into hypereutectic aluminum-silicon alloys with silicon contents in the range of 18 to 35%. A rotor prevents surface agitation of the liquid zone and consequent air entrapment, and permits the graphite powder to be introduced below the surface of the melt at the shearing zone. After mixing, the composite slurry is bottom poured into a mold and squeeze cast (Gibson et al., 1982). Das and A.J. Clegg are now planning to introduce short fibers into the matrix metal through the compocasting process.

The metal matrix composite work led by Das has been supported by the UK's Science and Engineering Research Council (SERC); industries have shown increasing interest. Other research at Loughborough includes Dr G.F. Modlen's characterization of the alignment and viscosity of short fibers contained in a suspension flowing through a convergent channel. This work is relevant to the fabrication of aligned short fiber composites.

Univ. of Bath

Composite materials research at the Univ. of Bath (Claverton Down, Bath BA2 7AY) is conducted primarily by the School of Materials Science. Prof. B. Harris is the head of the school, which has 10 faculty members. Research at the school covers physical metallurgy, oxidation and corrosion, fracture, and material structural studies based on acoustics and ultrasonics. Four faculty members, three research officers, and six research students participate in composite research. Their activities center on high performance composites, acoustic emission monitoring, lightweight material, and flexible composites.

Work on high performance composites for structural applications stresses mechanical properties, with particular emphasis on environmental effects due to temperature, moisture, fatigue, and ultraviolet light. The work has been sponsored the UK's Ministry of Defence, the Royal Aircraft Establishment, and Elf-Aquitaine, a major French petroleum company. Researchers have studied the effects of moisture on the performance of carbon, Kevlar®, and glass composites fabricated and tested under nearly identical conditions. Moisture effects are being studied on carbon-Kevlar and carbon-glass hybrids. The purposes of the hybrid studies are to provide a basic understanding of the materials' behavior and to improve their performance. Two types of resin systems for hybrid laminate composites are being considered: thermally stable resins for the carbon-Kevlar hybrids, and resins easily fabricated at relatively low temperature, but with poor thermal resistance for the carbon-glass hybrids. In addition, researchers soon will begin to examine the fatigue behavior of carbon Type I-Type III hybrids based on the short fiber system supplied by the UK's Propellants, Explosives and Rocket Motor Establishment.

Elf-Aquitaine is enthusiastic about the development of resins with mechanical and thermal characteristics suitable for composites applied in oil drilling. The company has already obtained a license from Toray Co. of Japan to manufacture carbon fibers.

Another area of composite research aims to establish acoustic emission monitoring by amplitude distribution analysis--a reliable method of nondestructive examination for composites. Sponsored by the Polymer Engineering Directorate of the SERC, the program is especially concerned with storage vessels and pipings constructed of chopped strand glass mat-polyester. Because of their corrosion resistance, reinforced plastics once were substituted for steel in such applications. But modern steels corrode less easily, and fiber reinforced plastics must compete on straight cost-effectiveness.

According to the researchers at Bath, a reliable and versatile technique of nondestructive examination would encourage the use of composites. Manufacturers of reinforced plastics could demonstrate that their products meet performance standards, and if deterioration in service could be detected, the acceptability of reinforced plastics would be much improved. Increased confidence in the material would favor the adoption of more economical designs and would help lower costs, often the principal obstacle in using reinforced plastics instead of steel.

At Bath, the acoustic emission signal processing is based on two methods: event counting and amplitude distribution analysis. The amplitude distribution of the transmitted acoustic signals is presented as a histogram showing the number of events in a given amplitude interval. Such information can also be processed to show a cumulative display on a linear or logarithmic scale. It has been shown that if pulse amplitudes are randomly distributed, the number, N(A), of pulses with amplitude greater than A can be represented by

$$N(A) = (A/A_o)^{-b} ,$$

where A_o is the lowest detectable amplitude and b is a constant. The log-log plot therefore is a straight line of slope -b. When one tests simple homogeneous materials in which one micro-failure event dominates, a straight line plot is often observed. A high value of b indicates emissions from many small events, whereas a flatter curve implies that high amplitude events predominate. The literature suggests that in composites low values of b can be unambiguously associated with fiber failures (defined as high energy events), while large b values relate to nonfiber failure events such as resin cracking or debonding.

During tensile loading of test coupons, Harris and coworkers have studied the amplitude distributions of acoustic emissions from glass reinforced plastics of several different kinds. The researchers showed that the structure of laminates and environmental conditions dominate the acoustic emission pattern observed. Furthermore, they concluded that no simple correlations can be made between microfailure events in the composite and the amplitude distributions of the emissions. The cause, they believe, is that the amplitude of a fiber failure event depends on the condition of the interface between the local fiber and resin, the extent of debonding, the presence of an environment hostile to the glass, and other factors that they have not studied. On the other hand, they found that the acoustic emission behavior of good quality laminates is highly consistent, and that acoustic emission can be used at an early stage in loading to distinguish between a defective and a sound sample of a well-characterized material. Thus, the researchers strongly believe that it may be possible to understand acoustic emission patterns from glass reinforced plastics only if there is already substantial information about the behavior of similar materials under known conditions.

The development of lightweight material is being sponsored by British Petroleum; the aim is to design and fabricate composites that have high specific modulus so that they can be used in building. Researchers are imitating the open cellular structure of wood by suitable arrangements of reinforcing material in resin. The reinforcements provide stiffness, while the open structure is responsible for the low density of the composite. The School of Materials Science is studying flexible composites for inflatable structures such as tents. Woven textile materials coated with plastics have been used to improve in-plane shear, creep, fracture, and environmental resistance.

Prof. J.R. Willis of the School of Mathematics is also doing composite materials research. His main interest is the study of variational methods for determining the bulk properties of composite materials.

<u>References</u>

Das, A.A., and S. Chatterjee, *The Metallurgist and Materials Technologist.*

Gibson, P.R., A.J. Clegg, and A.A. Das, *Foundry Trade Journal* (February 1982), p 253.

T.-W. Chou

OPERATIONS RESEARCH

THE 4TH EUREDATA CONFERENCE

Euredata, a nonprofit association of reliability data bank organizations, was formally launched in 1979 and now has 24 member institutions. The objective of Euredata is to coordinate the development and operation of reliability data banks, and in particular:

- To promote data exchange between member organizations,
- To establish a forum for exchange of experiences in operating such data banks,
- To encourage the adoption of compatible standards and definitions for reliability data, and
- To establish standards for data authentication and validation.

Members of Euredata include universities, private industries, government agencies, and European community groups (such as the European Space Agency)--organizations who collect data in the areas of nuclear energy, electronics, telecommunications, transportation, offshore installations, and the oil, gas, chemical, and automotive industries. The information is used to infer the reliability of components and systems, to describe the behavior of materials, and to establish case histories of incidents. Membership is limited to organizations in Europe operating reliability data banks. Euredata has been involved in international data collection in certain specialized fields, such as the Offshore Reliability Data Handbook (OREDA) project described below. Euredata also sponsors various conferences and seminars, such as the 4th Euredata Conference (23 through 25 March 1983, Venice, Italy).

Approximately 225 people attended the conference, and about 70 papers were presented in parallel sessions. About 10 papers were directly concerned with data banks; the rest were devoted to reliability, availability, and safety and risk management. In this article, I shall describe a few papers in detail; copies of the full conference proceedings can be obtained from Euredata, c/o ENI, Dr. Viviana Columbari, Via Triulziana 40, 20097 S. Donato Milanese, Italy. The price is IL 150,000 (about $106).

Risk Management

Some of the most interesting papers were concerned with probabilistic risk assessment and the management of risk in design and operation of large, complex systems. Risk assessment studies are conducted in an attempt to quantify the exposure of workers and the population at large to hazards related to operation of such systems. Quantification is being imposed by environmental and health and safety regulations, and is starting to be used in statements of liability limits granted to operators of hazardous technical systems. The most pressing demands stem from public controversies about plant siting decisions and choices among alternative technologies.

Recently, many risk assessment studies have been conducted, some at considerable cost. For example, risk assessments for about 20 commercial nuclear power reactors have been published in the US, and similar studies have been made in the Netherlands, Sweden, and Germany; a risk assessment of a nuclear power plant might cost several million dollars.

Risk studies are becoming common in other hazardous industries, such as offshore drilling and certain chemical industries. In "Probabilistic Risk Assessment: Use and Misuse," G. Mancini and G. Volta (Commission of the European Communities Joint Research Center, Ispra, Italy) stated that despite the amount of work on risk assessments, their interpretation and use seems to be increasingly controversial in Europe. As an example, they cited European experts' skeptical attitude toward the initiative by the US Nuclear Regulatory Commission (NRC) and the US nuclear industry to set up guidelines for probabilistic risk assessment procedures for nuclear power plants. The authors said that a reappraisal is needed, including modeling the components of risk and linking them with decisions. Three major points were stressed:

- The distinction between "diffuse risks" associated with routine operation of plants and "major technological risks" related to possible disastrous accidents,
- The implications of the distribution in time of the major risks, and
- The logic of the decision processes concerning major risks.

Mancini and Volta contended that because the natures of diffuse and major risks

differ intrinsically, fundamentally different models must be used for each. Moreover, decisions such as those about licensing nuclear plants are necessarily based on limited knowledge of the probabilities involved, and therefore are not quite the same as decisions based on conventional expected loss.

A. Cardinale, P. Grillo, and S. Messina (Snamprogetti SpA, Milan, Italy) presented a paper on "Risk Management in Project Execution." They described how Snamprogetti has been implementing risk management programs for a variety of clients--programs designed to meet control authority requirements and company policies. They pointed out that fulfillment of applicable codes and standards is not always sufficient to assure the safety of complex plants, so their company, as part of its risk managment programs, also assumes the role of a consultant to clients sponsoring the work. The authors described the various components of a risk management program, categorized the programs by levels of comprehensiveness, discussed elements of a safety analysis that should be conducted at early stages of the design of a plant, and described "safety verification" checks that should be performed as the project matures. Interestingly, they concluded the paper with a discussion of some limitations of risk analyses and cautions that should be exercised in their use.

Data Banks

A number of papers were devoted to discussions of data bases. O. Tveit, T. Moss, and E. Østrby (Det Norske Veritas, Norway) reported on the OREDA project. Risk assessments and safety analyses for offshore systems should be based on accident and failure information from such installations, and not on generic data from onshore industries, as has been done in the past. The authors said that in Norway and other European countries, there would be strong opposition to mandatory data collection procedures such as those of the FIRS system required by the US government for companies operating in the Gulf of Mexico.

The OREDA project's objective through 1984 is to establish a comprehensive base of reliability information by extracting data from company failure and repair records already existing in the offshore industries. As a longer term goal, there are plans to publish summaries of the data in a handbook. However, individual companies with information on their own operations are reluctant to open up their data bases to others. There are several reasons: data exchange would take a great deal of work, there are confidentiality problems, and legal or governmental authorities might use accident or failure data against the companies. As a result, the project has been developed around a committee of individuals from the various cooperating companies; these people prevent unauthorized release of information and take steps to guarantee confidentiality. Further, the OREDA project restricts its work to items on the component level, especially those used extensively in the offshore industry.

Several other data banks were described. J. Anesz et al. (Commission of the European Community Joint Research Center, Ispra, Italy) discussed the European Abnormal Occurrences Reporting System (AORS). AORS has been established as a resource for safety assessments by utility companies and nuclear licensing authorities. The data base contains information on events or failures that could have consequences for the safe operation of nuclear power plants. AORS is one of the subsystems of the European Reliability Data System, along with the Component Event Data Bank, the Operating Unit Status Report, and the Generic Reliability Parameter Data Bank. The AORS data are obtained from independent national data systems in France, Italy, Sweden, and the US. In the near future, systems in the Netherlands and Germany will also be put on line. The job is complicated because the various data sources supply different types of information and do not use the same inclusion criteria. At one extreme, the NRC system of the US generates about 50 occurrences per year per plant; at the other, some European national systems report only a few cases each year. The AORS workers try to encourage the various national reporting agencies to adopt more uniform standards and edit the reported data before input to the data bank.

The Failure and Accident Technical Information System (FACTS) data bank was described by I. Bockholts (Netherlands Organization for Applied Scientific Research). FACTS contains technical data about incidents occurring during the production, storage, shipment, use, or disposal of dangerous materials. "Near misses" also are included. The data collection covers worldwide information from all open sources. The occurrences are cross-indexed in various ways. For example, incidents are classified in seven categories of type of event, such as natural (earthquakes or lightning, for instance), human failure, and technical failure.

Several papers dealt with analyses of risks associated with specific systems. The range of these papers is suggested by a sample of titles: "Assessment of the Risk of a Plutonium Laboratory," "Transport of Hazardous Materials in the UK," "The Swiss Electrical Rail Network as a Potential Nuclear Transportation System," "Safety Analysis of an LPG Coastal Storage Facility," and "Analysis of Pipe Failures in Swedish Nuclear Plants." In addition, about 20 papers were concerned with more traditional reliability and availability research. The work included development of simulations, mathematical models, computer routines for fault-tree analyses, statistical analyses of failure data, and stochastic models of failure processes.

Generally, the reports reflected state-of-the-art research in a wide range of topics related to reliability. I felt there could have been more emphasis on sharing "lessons learned" from concrete experiences, rather than so much reporting of plans for future studies and data bases. It seemed that the researchers were interpreting risk too narrowly. Many authors implicitly defined risk as the "probability of occurrence of an event times the consequence of such an event." If one imagines a simple Bernoulli model for defining risk as expected loss, then a second term involving the beneficial side of nonoccurrence of the event is also appropriate; this seemed to be totally ignored in the papers I heard. Finally, there appeared to be little concern about collection of general background or cohort data. How can one do much with valve failure data, for example, if one does not know how many valves were operating? It is unfortunate that the full potential of many data bases devoted to incidents may not be realized because little or no general population ("nonincident") information has been collected.

D.R. Barr

NORTHERN BRITISH O.R. CONFERENCE

The Yorkshire and Humberside (UK) sections of the Operational Research Society hosted a conference near Sheffield from 28 through 30 March 1983. The meetings seemed somewhat unusual in that almost all sessions emphasized applications of operations research (O.R.) in a very broad range of topics; few papers went into much technical detail.

There was discussion about "the crisis in O.R."--i.e., the apparent narrowing recently of O.R. employment opportunities in the UK. Several speakers suggested that in order to survive this crisis, O.R. must broaden its discipline to include parts of management science, psychology, and social science. I would describe this as a move into relatively "soft" applications areas, as compared with the traditional "hard" applications related more to science and engineering. Of course, one of the strengths of O.R. has been the discipline's lack of rigid boundaries, a characteristic reflected by the continuing debates about the definition of O.R. The conference was attended by about 50 delegates representing a broad spectrum of interests within O.R. Most of the attendees were young professionals working for a variety of industrial firms in the UK; only about 10 listed an affiliation with educational institutions. To suggest some of the concerns of those attending, I shall describe a representative sample of the papers delivered; a review of what the young workers are doing may provide information about a current trend in British O.R.

A request by Prof. Rolfe Tomlinson (Warwick Univ., UK) indicated the persistent concern about the boundaries of O.R. He asked attendees to take a well-known personality test (PF 16) to provide data about "what constitutes a good O.R. worker." According to Tomlinson, O.R. job advertisements in the UK put enormous emphasis on a variety of managerial and social skills, technical skills being taken for granted. He asked whether O.R. professionals aren't therefore really more like managers than scientists, and was led to attempt to determine more precisely what constitutes the O.R. professional. The question arose in a study of the problems of introducing O.R. into developing countries, which requires finding people in such countries who have characteristics similar to those of O.R. professionals. But little scientific work has been done to identify such traits. Therefore, Tomlinson, a graduate student of his from Nigeria, and a psychologist in the School of Industrial and Business Studies at Warwick are administering the personality test to operations researchers in the UK.

One session was devoted to O.R. and personal construct theory. Personal construct theory is a psychological model of how humans operate in the real world. Even though the theory was developed by an American psychologist, George Kelly, it was more immediately

accepted in Britain than in the US, and Britain remains a particular stronghold of personal construct theory. The basic proposition is that each person operates as a scientist, attempting to make sense of his external world by developing hypotheses (or models) to explain it. As time passes, the models are revised to improve their agreement with the real world as the individual perceives it. To communicate with another person, one must try to find out what that person's models are. Psychologists may try to elicit such information in the form of constructs which are "bi-polar contrasts" that discriminate among the elements in a person's universe. The repertory grid is one tool for analyzing a person's constructs. For example, a two-dimensional table might be prepared with a person's constructs related to jobs (e.g., easy/hard, interesting/dull, exciting/boring) along one dimension and job types (e.g., assembly line, filing, computer operation) along the other. Then scores, say from 1 to 10, are assigned to each cell of the grid. It is claimed that various statistical analyses of such data (cluster analysis or "correlation" analyses, for instance) will help the psychologist understand a subject's "operating system" of models. Dr. Gavin Dunnett of the Center for Personal Construct Psychology (Sheffield, UK) and Prof. G. Fielding (Sheffield Polytechnic) discussed how personal construct theory could be used in management and decision making situations. They obviously view the theory as a potential O.R. tool.

Mr. P.N. Coe gave an evening lecture, "The Development of an International Athlete." He discussed how he coached his son, Sebastian Coe, the Olympic gold medal winning runner. Mr. Coe set up for his son a program that included carefully drawn schedules of training, as well as thoroughly researched decisions about which competitions to enter. The program started when Sebastian was about 12 years old and is still being followed (he is now 22). Mr. Coe, who had never coached a runner before starting with his son, found it necessary to learn about several fields, such as physiology, biochemistry, and sports medicine.

Drs. P. Keys and M. Jackson (Univ. of Hull, UK) presented the paper "Problem-Solving Methodologies--Theory and Practice." Keys and Jackson discussed categorizing problem contexts with respect to two factors--the systems and the decision-makers. Systems were divided into two sets, one containing simple, mechanical problems, the other having complex, open-ended problems. Keys and Jackson call these mechanical and systemic, respectively. Decision-making bodies were classified as unitary or pluralist. A group of decision-makers is unitary if its members agree on a common set of goals for the whole system under consideration; it is pluralist if they do not agree on a common set of goals. Problem contexts are seen as being in one of the four categories formed by specifying the system and decision-maker categories.

The object of the classification of problem contexts is to allow specification, in very general terms, of methods of solving each type of problem. According to Keys and Jackson, mechanical-unitary problems can be adequately dealt with using the techniques of classical O.R., together with the "sister disciplines," systems engineering and systems analysis. For problems of the systemic-unitary type, "the tools provided by cybernetics [described as black-box techniques, variety engineering, and negative feedback] give the problem solver the best chance" of solution. Mechanical-pluralist problems require methods that attempt to bring about a "synthesis" among decision-makers so that action can be taken; methods developed by C.W. Churchman were cited. Finally, systemic-pluralist problems require methods such as R.L. Ackoff and P.B. Checkland's "soft" systems approaches--interactive planning, for example. The authors elaborated on the practical benefits of using the above analysis; they concluded:

"O.R. is regarded by many as being in crisis. If O.R. is taken to be classical O.R., this is indisputable. Classical O.R. provides the practitioner with an approach suitable for solving problems only in mechanical-unitary contexts. If, however, the definition of O.R. is widened to embrace other systems based methodologies for problem solving, then the diversity of approaches presents the practitioner with increased competence and effectiveness in a variety of different problem contexts."

Prof. T. Scheurer (Univ. of Manchester, Institute of Science and Technology, UK) presented a paper entitled "Interactive Modelling: A General Purpose System Based on Tocher's Philosophy," in which he described a general purpose interactive modelling system he has developed. The system is based on K.D. Tocher's modelling principle that a fundamental distinction should be made between a model of a certain reality and problems about that reality. According to Scheurer, a model

is just a set of variables and a set of relations the variables should satisfy. There are often more variables than relations, so the variable values must be determined partly by the modeller's choice and partly by the relations. A "problem" consists of selecting a suitable set of input variables, assigning arbitrary values to them, then solving for the values of the remaining variables.

The modelling system, which Scheurer calls CMS, works as follows: first, the user specifies a set of relations in the form of an underdetermined system of equations. At this stage, no distinction is made between input and output variables, and the flow of calculations is still underdetermined. For each computer run, the user selects a set of input variables and assigns values to them. The system then solves for the remaining variables. A set of input variables is accepted by CMS only if it is consistent with the system of equations. At any stage, the user can backtrack, choose another input set, and solve again. Thus the user may determine and solve every problem consistent with the equations. Scheurer remarked that determining which problems are consistent and which are not is a non-trivial task which sheds light on the structure of the reality studied.

It is not clear whether the O.R. community will embrace the expansion of their discipline which is implied by these papers. Certainly there is risk in venturing too far astray, away from established practice and methods. But there is also potential loss to the profession if adventure and exploration are not encouraged. It cannot be denied that there are interesting and important problems in these and other "soft" areas; why shouldn't O.R. researchers tackle them?

D.R. Barr

PHYSICS

THE PHYSICS OF TRANS-POLYACETYLENE

The physics of trans-polyacetylene was a major topic at the International Conference on the Physics and Chemistry of Conducting Polymers. (For a discussion of chemistry research presented at the same conference, see the article by Wynne and Stannett elsewhere in this issue.)

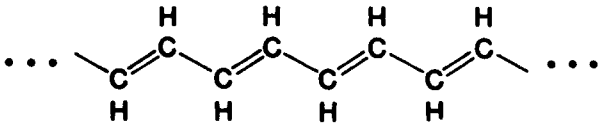
The 20 talks and 40 posters in this area described new work on the structure and on the optical, electrical, and magnetic properties of trans-polyacetylene. The properties are the basis for two proposed applications: undoped trans-polyacetylene used as a semiconductor for low-cost photovoltaic conversion of solar energy, and doped trans-polyacetylene as a lightweight synthetic metal or battery electrode.

When trans-polyacetylene is doped, the electrical conductivity increases. Some time ago, the creation of solitons was proposed to explain this characteristic. In later experiments, doped trans-polyacetylene showed several properties calculated for solitons, but alternative explanations also were offered. At the conference, several contributors reported the experimental observation of soliton characteristics in illuminated undoped trans-polyacetylene. The similarity of the results in both doped and illuminated trans-polyacetylene is evidence that solitons play an important role in determining the electronic properties.

This article discusses presentations that dealt with the structure of trans-polyacetylene and the nature of its solitons.

Structure of Trans-polyacetylene

Trans-polyacetylene is a linear conjugated polymer, trans-$(CH)_x$. Each carbon atom contributes one π-electron (the more weakly bound electron in a double bond) to a band of states about 10-eV wide. The π-electrons in the half-filled band are delocalized along the chain, so undoped trans-$(CH)_x$ is a semiconductor. When doped, it has the electronic properties of a metal. The π-electron band is split in two by a gap between the occupied valence band and unoccupied conduction bands. Successive carbon-carbon bonds are not the same length, but alternate:



(In later diagrams, the carbon and hydrogen atoms will not be shown explicitly.)

The chain is conveniently diagrammed with alternating pure single and double bonds. The polymer has two stable forms: one with the mirror image of bonds of the other. The single and double bonds have a bond-length difference of about 0.15 angstroms. Previous x-ray diffraction studies of trans-$(CH)_x$ showed a bond-length difference

of 0.05 angstroms. T.C. Clarke (IBM, CA) and M. Mehring (Univ. of Stuttgart) each used ^{13}C nuclear magnetic resonance measurements to estimate the two bond lengths by another method. Each obtained a bond-length difference in agreement with the x-ray results. The trans-$(CH)_x$ form most studied is made by the two-step process of Shirakawa and Ito. First, acetylene gas is polymerized by a Ziegler-Natta catalyst to a form cis-$(CH)_x$. The polymer chains form microcrystallites, fibrils of about 300-angstrom diameter and 5,000-angstrom length, with the chain and fibril axes parallel. The fibrils are matted and have no overall preferred direction. Then the cis isomer is converted to the trans isomer by a brief exposure to heat (T>150°C). P. Robin (Thomson-CSF, Orsay, France) described x-ray measurements showing that the chain separation (perpendicular to the chain axis) gradually shifts during the isomerization. He concluded that trans-$(CH)_x$ segments develop throughout the microcrystallites and do not form an intermediate mixture of cis- and trans-type crystals. Also using x-ray methods, R. Baughman (Allied Corporation, NJ) studied the structure of alkali-metal doped trans-$(CH)_x$, and A. Epstein (Xerox, NY) studied the dopant-induced isomerization of cis-$(CH)_x$.

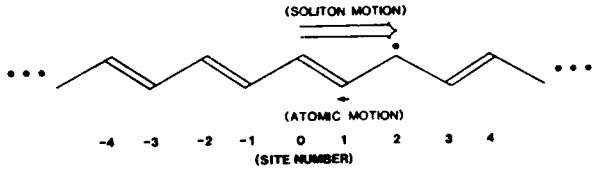
Resonance Raman scattering measurements of trans-$(CH)_x$ have shown broad lines, as though the bond-alternation pattern has some relatively short lengths along the chain. S. Lefrant (Univ. of Paris-South, Orsay, France), H. Kuzmany (Univ. of Vienna), and E. Mulazzi (Univ. of Milan) each discussed ways to fit the model to the data. E. Mele (Univ. of Pennsylvania) proposed another explanation for the broadening: rapid luminescence of excited electrons in addition to the resonance Raman scattering.

Solitons in Trans-$(CH)_x$

The presence of solitons in trans-$(CH)_x$ had been proposed to explain important features of the magnetic, electrical, and optical properties of trans-$(CH)_x$. A soliton is a boundary on a single chain between the two possible patterns of bond alternation. The term soliton is used because the mathematics describing the boundary is similar to that of certain nonlinear wave equations and their soliton solutions (see articles by D. Mosher, *ESN* 36-9 and 36-10 [1982]). A soliton only a single site wide can be drawn as

The dot represents the π-electron of the center site when the soliton is uncharged. Chemically, the neutral soliton is a radical and a charged soliton is an ion.

The soliton has several particle-like properties. It is localized and can transport charge or spin. While it need not have any net motion, it can move along the chain. Whenever the center is at an even-numbered site, the bonding pattern is locally the same, and no additional bonding energy is required:



As the soliton moves (upper arrow in diagram), the atoms of the chain need to move only a little (lower arrow in diagram). The activation energy for the motion is small, so the motion can be rapid.

The stability of the soliton is also particle-like. Because it is a boundary, an isolated soliton cannot disappear. But it can disappear when a soliton-anti-soliton pair annihilates in a particle-like event.

A soliton is not as small as the single site of the diagrams above. One bond alternation pattern changes gradually into the other, with a transition region of nearly uniform bond lengths near the center site. Contributions to the spin or charge of the soliton are found not just at the central site, but also at nearby sites to which the electronic orbital of the soliton extends. A calculation by Su, Schrieffer, and Heeger used a model with both possible sizes of the soliton the same and predicted a soliton radius (one-half its length) of five to 10 sites. J.L. Bredas (Univ. of Namur, Belgium) presented recent quantum chemical calculations using a more general Hamiltonian (the mathematical expression of energy from which the soliton motion is derived). He predicted that the electronic orbital is about as large as predicted by Su, Schrieffer, and Heeger

but that the bond transition region is half as large. Bredas' work places on a firmer foundation several calculations of other soliton properties--calculations that depend on the size of the electronic orbital. Bredas' methods may also be extended to realistic calculations of other details of the soliton's properties.

The charge and spin of the soliton are determined by the occupation of its localized electronic orbital. If there is one electron, as diagrammed above, the soliton is neutral and has the spin-½ of the unpaired electron. If there are no electrons or two, the soliton is charged positively or negatively. A charged soliton has no spin, for there are no unpaired electrons associated with it. This spin-charge relation differs from the more common one for electrons or holes in semiconductors or molecular solids. Usually, the electron or hole excitations carry both charge and spin-½ at the same time.

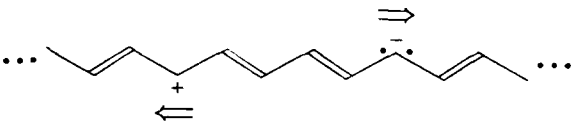
The soliton electronic orbital is a nonbonding π orbital between the bonding and antibonding π-electron bands; its characteristic energy is near the middle of the gap between the valence and conduction bands. Less energy is required to add an electron (or hole) to a neutral soliton than to the conduction (or valence) band. In addition, charged solitons can be created with less energy than that required to add charges to one of the bands. The electrical and optical properties of trans-(CH_x) depend on these characteristics. Doping of trans-$(CH)_x$ proceeds by the transfer of charge to the polymer chains from suitable electron-donating or -accepting dopants. First, the neutral solitons already present are converted to charged solitons; then additional charged solitons are created.

In early experiments, trans-$(CH)_x$ from Shirakawa's process showed a pattern consistent with the presence of a few neutral solitons in undoped trans-$(CH)_x$ and the creation of charged solitons by doping. Undoped trans-$(CH)_x$ has a few mobile, localized spins created by defects in the isomerization process. The spins disappear as doping begins. No more spins appear for some time during subsequent doping, while the many added charges increase the conductivity by many orders of magnitude, from about 10^{-5} $ohm^{-1}cm^{-1}$ to more than 10 $ohm^{-1}cm^{-1}$. Finally, at dopant levels of about 7 mol%, some electron-like magnetism appears. (The nature of the third doping stage will not be discussed here.)

Other experiments measured additional soliton properties. The mobile spins in undoped trans-$(CH)_x$ usually move along a single chain with the solitons and only rarely hop between chains like electrons. Lightly doped trans-$(CH)_x$, with more solitons than undoped trans-$(CH)_x$, also has additional strong optical absorptions. The electronic transition to the electronic orbital of the soliton is at about 0.8 eV, near the middle of the optical gap. Vibrational bands of the chain near the soliton are found in the infrared.

By themselves, the optical experiments on trans-$(CH)_x$ may have other explanations. For example, D. Baeriswyl (ETH-Hönggerberg, Zurich) discussed how charged dopants could modify the vibrational and electronic spectra of soliton-free chains to spectra like those in the presence of solitons.

The possible influence of charged dopants would be avoided if charged solitons could be created in trans-$(CH)_x$ without doping. Trans-$(CH)_x$ is photoconductive for light with enough energy to excite an electron across the band gap. Perhaps the additional conductivity is due to charged solitons created from the photo-generated electron-hole pair. Molecular dynamics calculations showed that an electron-hole pair could create a pair of separated charged solitons in a few picoseconds:



J.R. Schrieffer (Univ. of California at Santa Barbara) described the quantum mechanics of how a photo-generated soliton-anti-soliton pair nearly always separates into charged solitons rather than neutral ones. The presence of photoconductivity was suggestive; the experimental question was whether enough solitons live long enough to permit experiments other than photoconductivity.

There were several reports about the measurement of soliton characteristics in illuminated trans-$(CH)_x$. J. Orenstein (Bell Laboratories, NJ) described the optical absorption of trans-$(CH)_x$ after a laser pulse. Both features of the soliton were observed:

the infrared absorption of the local vibrational modes and the mid-gap electronic absorption at about 0.5 eV. In addition, a decline in the interband absorption due to the creation of the solitons was observed. The absorptions were in correct proportion to each other at all experimentally observable times, even when their decay had a complex time dependence. The estimated experimental quantum efficiency at short times is about 1. Most solitons recombine within 1 ms, but some persist for as long as 10 ms. Both the small shift in the location of the mid-gap absorption and the lifetime of the photo-generated solitons remain to be explained, but overall the absorption measurements of illuminated and doped trans-$(CH)_x$ agree well.

D. Moses (Univ. of California at Santa Barbara) reported evidence for the motion of the charged solitons. He monitored the decay of the polarization of the interband absorption that is induced by solitons created by a polarized laser pulse. The diffusion constant then estimated is comparable to that previously measured for neutral solitons, about 10^{-2} cm^2/s. A.J. Heeger (Univ. of California at Santa Barbara) described experiments that show no photo-induced electron spin resonance signal and set an upper limit on its magnitude. The limit confirms the no-spin property of the long-lived charged solitons. The evidence for solitons in illuminated trans-$(CH)_x$ included an association with charge transport without spin, the infrared vibrational modes, and the midgap absorption.

Heeger also described electrochemical methods of measuring the energy levels for the transfer of charge to undoped and doped trans-$(CH)_x$. More energy was needed to inject charge when there were no neutral solitons than to remove it after charged solitons had been created by doping.

Several additional studies on the magnetism of undoped trans-$(CH)_x$ were reported. L. Dalton (Univ. of Southern California) used electron nuclear double resonance to study the spin density of mobile neutral solitons. M. Nechtstein (Centre d'Etudes Nucléaires de Grenoble, France), M. Mehring, N.S. Shiren (IBM, NY), and W.G. Clark (Univ. of California at Los Angeles) have studied both the mobile and nonmobile spins--especially spin relaxation rates. Some of the mechanisms are not yet understood.

The number of scientists studying the physics of trans-$(CH)_x$ has increased since the previous conference. Their uses of experimental techniques new to trans-$(CH)_x$ have expanded the understanding of this electroactive polymer, but many experimental and theoretical questions remain. More results are expected at the 1984 conference in Italy.

L.L. Peebles
NRL, Washington, D.C.

SPACE SCIENCES

ESA APPROVES INFRARED SPACE OBSERVATORY

The European Space Agency (ESA) selected its next space mission at its annual meeting in March. The competition was among five possible missions relating to broad areas of space science and astronomy: DISCO, a solar observatory to study the sun's internal structure and to monitor interplanetary space; the Infrared Space Observatory (ISO), which would use a cooled telescope for infrared observations from space; Kepler, a Mars orbiter; Magellan, an astronomical observatory with a versatile ultraviolet spectrometer; and X-80, a mission to measure the spectrum and temporal behavior of x-ray emitters. An initial, or Phase-A, study had been completed for each mission; factors such as scientific objectives, possible instrumentation, and orbit were recommended for consideration.

The ESA mission selection process involves progressive committee considerations, where the recommendations of one committee are passed on to be sustained or altered at the next level. In first-round deliberations, DISCO was chosen over Kepler by the Solar System Working Group (SSWG), and ISO was chosen from the three remaining astronomy missions by the Astronomy Working Group. At the next level of consideration, ISO was chosen over DISCO by the Space Science Advisory Committee, and the decision was sustained by the Science Program Committee at the highest level. As a result, ISO will now begin a Phase-B study; more detailed instrumentation requirements will be developed, and accurate costing will take place.

Needless to say, the ESA mission selection process involved some surprises and controversies. In a real sense, the selection process is not yet over. Evidently the French, who are highly influential in ESA, showed unusual favoritism toward DISCO. This, coupled with the somewhat splintered

support of the planetary science community for Kepler, may have assured SSWG's selection of DISCO. ISO, not X-80, emerged as the mission preferred by the astronomers. X-80 may have been hurt by the Italians' recent decision to have their own x-ray mission, SAX. During the evaluations, Magellan ran into a serious problem regarding estimates of particle backgrounds that would reduce claimed ultraviolet measurement sensitivities by as much as two orders of magnitude. Finally, the integrity of the whole selection process has been questioned because of an alleged overrepresentation of astronomers, and thus a bias for astronomy, on high-level ESA committees. (Those familiar with the NASA selection process will perhaps recognize such problems as endemic to the task of mission selection.)

With its selection, ISO becomes the fifth ESA program under development. The others are GIOTTO, ISPM, participation in the Space Telescope, and Hipparcos. Each mission costs about $250 million, or about 2½ times ESA's annual budget for space science. Budget limitations and mission development time push the launch for ISO into the early 1990s. A danger is that ISO's current estimated cost is about as large as ESA can bear. If the Phase-B study concludes that a significantly higher cost is required (beyond inflation), the expectation is that the ISO mission will be cancelled and that a switch to DISCO is likely.

ISO would be an infrared observatory with possible real-time control and an operational lifetime of at least 1.5 years. The main instrument would be a 60-cm-diameter telescope with a complement of photometric and spectroscopic instruments for measurements in the wavelength range of about 2 to 120 μm. The telescope and instruments mounted at the focal plane would be cooled by a dual cryogenic system using liquid hydrogen and superfluid helium. The required cryogenic technology and the long lifetime of the mission have made the scientific community skeptical about the optimism and cost analysis in the ISO Phase-A study.

The ISO satellite would be a three-axis-stabilized free-flyer, designed for an Ariane-2 launch. The planned orbit would be elliptical, perigee at 2,000 km and apogee at 39,000 km, would be inclined 5 degrees with respect to the equatorial plane, and would have a 12-hour period. The spacecraft would be operational except when immersed in the earth's main radiation belts. The orbit permits essentially real-time control of the satellite when two ground stations are used.

The model instrument payload for ISO includes a camera system, two spectrometers, and a photometer. Each instrument operates in a different infrared wavelength range with an impressive resolving power. The camera system consists of an InSb 32×32 cathode imaging detector (CID) array operating in the wavelength range 1 to 5 μm (and possibly a second array in the range 6 to 12 μm) and using both narrow-band and continuously variable filters. The spectrometers are rapid-scan Michelson interferometers encompassing the wave length range 2 to 70 μm, with a resolving power of $\lambda/\Delta\lambda = 10^2$-$10^5$. The photometer will resolve three or four bands in the wavelength range 8 to 120 μm.

The instruments will operate in the 8°K temperature environment of the focal plane assembly. The telescope will have a 20-arcmin field of view that will be apportioned to the instruments so that each has at least a 3-arcmin unobstructed field of view. During its lifetime, ISO will observe the entire sky several times and make detailed observations of selected objects. The substantial learning process expected to take place during the mission will be exploited late in the mission through use of the real-time operational capabilities for dedicated studies.

Because of its warmth, the earth's atmosphere emits a significant amount of thermal energy at infrared wavelengths. In addition, the atmosphere is opaque to incident radiation from external sources at most infrared wavelengths. These two factors impose major limitations on ground-based telescopes or balloon campaigns--limitations that are avoided by making infrared observations from space. ISO's cooled telescope operating in earth's orbit is expected to have a sensitivity of two to four orders of magnitude greater than a 4-m ground-based telescope or a 1-m balloon-borne telescope. ISO would also have an enormously greater spectral range.

Infrared observations of stars, the interstellar medium, galaxies, and other astronomical objects can provide unique information not available at other wavelengths. Dust and many molecules and atoms in the temperature range of a few degrees to a few thousand degrees Kelvin radiate most of their energy at infrared wavelengths. Dust is abundant in all galaxies and is generally opaque to visible and ultraviolet radiation. Thus, in the presence of dust, infrared observations can often probe far more deeply into an astronomical object. The

distribution of mass in large regions of the sky can be better inferred at infrared wavelengths. Star formation and perhaps the development of planetary nebulae from interstellar dust and gas can be studied. Star formation from the gravitational collapse of collecting material would involve a heating phase, prior to the onset of nuclear processes, that may be identified. Old, cooling stars can be studied in the infrared. Much cosmological information on the early stages of the universe derives from visible light observations of spectra that are significantly red-shifted and imply an expanding motion at relativistic speeds. These observations can be directly extended through measurements made at infrared wavelengths.

ISO is attractive and has widespread support because of its own merits and because it complements two other missions, the Infrared Astronomical Satellite (IRAS) and the Space Telescope. IRAS is a joint US, British, and Dutch mission that was launched in January 1983 after long delays caused mainly by difficulties in developing the cooling system. It is the first satellite dedicated to infrared astronomy. The primary objective of the mission is to carry out a reliable, all-sky survey in the infrared. ISO will be more sensitive than IRAS (perhaps by a factor of 100) and will be better suited to study specific locations in the sky. The all-sky surveys will identify interesting infrared zones that will be subjected to dedicated studies using the real-time operational capability of ISO. The Space Telescope, a world-class mission under development by NASA, is second in priority only to the Shuttle. Space Telescope promises unprecedented advances in all areas of optical astronomy. ISO would provide complementary observations to the Space Telescope in areas that are obscure to visible radiation because of high dust content. Particularly exciting is the prospect of making simultaneous observations of the same region of the sky with Space Telescope and ISO.

R.L. Carovillano

NEWS & NOTES

ACOUSTICS AND THE SEABED

In the 1940s and 1950s, acoustical physicists gradually discovered that the ocean was not quite infinite, homogeneous, and isotropic. Increasingly during the past two decades, scientists have been able to identify the many characteristics of the ocean that affect sound propagation. Research in the last 10 years has shown that propagation results can be inverted to provide immediate, remotely sensed physical details about the sea and its boundaries.

Acoustical properties of sediments, acoustical scattering, acoustical propagation studies, interface waves, and equipment developments were the main topics of a conference sponsored by the Institute of Acoustics' Underwater Acoustics Group. "Acoustics and the Sea-Bed" was held at the Univ. of Bath, UK, from 6 through 8 April 1983. The conference attracted some 125 attendees from 10 countries; there were 32 papers and 17 poster presentations.

While the conference treated many issues, a major interest was the increasing use of acoustics as a diagnostic tool for the ocean bottom--the topic discussed here. For example, D. Taylor-Smith (Marine Science Laboratory, Univ. College of North Wales), a geological engineer, spoke about deducing consolidation behaviors and permeabilities of sediments from seismic acoustic data, particularly shear wave velocities.

D.J. Thomson (Naval Underwater Systems Center, New London, CT) described an inversion technique using two impulse responses at different, near-normal angles to infer density and sound speed profiles in sediments.

L.A. Mayer (Dalhousie Univ., Halifax, Nova Scotia, Canada) pointed out that variations in acoustic properties of deep-sea carbonates ultimately result from fluctuations in oceanic conditions and from climatic changes.

A. Tsuchiya, M. Nishimura (Tokai Univ., Japan), and A. Kaya (Oki Electric Industry, Japan) described a new theory and laboratory model experiments to identify pulp micro-fiber inclusions in a sediment of clay particles. The researchers made the identification by measuring sound speed and attenuation at 200 and 800 kHz.

P.A. Crowther (Marconi Space and Defence Systems, UK) discussed the problem of separating backscatter due to sea-bottom roughness from that caused by sediment inhomogeneities and layering. His theory of statistics of the seabed surface and subsurface is a framework that clarifies the problem and may ultimately permit the inversion to be done.

I. Tolstoy (Knockvennie, Scotland) reviewed his research on coherent low frequency scatter at near-grazing incidence; the work suggests that a

layer of pebbles can be identified by forward scatter. H. Medwin told of laboratory experiments that go beyond theory to show coherent scattering over ridges and by randomly rough surfaces. The magnitude of the boundary wave has been used to determine the root mean square (RMS) roughness and the correlation length of the roughness elements.

J.M. Berkson and J.E. Matthews (Naval Ocean Research and Development Activity, Bay St. Louis, MS) tabulated physiographic provinces and their roughness parameters for the wave number (k) bands 0.003 to 0.03 m^{-1} and 6×10^{-5} to 3×10^{-1} m^{-1}. The parameters used were an RMS height that ranged from less than 1 m to 6.4 m for the regions studied and energy spectra of the form ck^{-b} for the roughness heights. The parameter b was found to range from 1 to 6.

In this brief survey, I have not been able to touch on the largest part of the meeting--the continuing problem of specifying the propagation models for the real ocean bottom, which has complex, spatially varying inhomogeneities. For detailed information about topics not described here, see the 436-page conference proceedings, edited by N.G. Pace. The book is available for £25 from Bath Univ. Press, Claverton Down, Bath, BA2 7AY, England.

H. Medwin
Naval Postgraduate School

INTERNATIONAL CONFERENCE ON METAL SCIENCES

The International Conference on Metal Sciences, ICMS-83: Deformation--All Aspects, was held from 17 through 19 March, 1983, at Ranchi, India. The conference was organized by the Research and Development Center for Iron and Steel of the Steel Authority in India Ltd., Ranchi, and by the Metal Sciences Division of the Indian Institute of Metals. The program included four sessions on all aspects of deformation mechanisms and the following individual sessions: Strain Ageing, Thermomechanical Processing, Superplastic Forming, Metal Forming, Deformation of Ceramics and Composites, and Surface Friction and Wear Studies.

V.S. Arunachalam, Scientific Adviser for the Ministry of Defense, gave the keynote address. Invited lectures were: "Grain Size Effects and Their Importance to Polycrystal Deformation Behavior," R.W. Armstrong (ONR, London); "Deformation Processing Maps," R. Raj (Cornell Univ.); "Deformation Textures," K. Lücke (Institut für Allgemeine Metallkunde und Metallphysik, Aachen); "Dynamic Strain Ageing," P.G. McCormick (Univ. of Western Australia, Nedlands); "Catastrophe Theory for Dynamic Strain Ageing," J.L. Strudel (École National Supérieure des Mines de Paris, Centre des Materiaux, Evry); "Dislocation Core Effects in Plastic Deformation," V. Vitek (Univ. of Pennsylvania, Philadelphia); "Plastic Deformation Near Absolute Zero," V. Ramachandran (National Aeronautical Laboratory, Bangalore); "Origins and Applications of Superplasticity," K.A. Padmanabhan (Indian Institute of Technology, Madras); "Recent Advances in Metal Forming Technology," A.K. Ghosh (Rockwell International Science Center, CA); "Impression Creep Behavior of Metals at High Temperatures," D.H. Sastry (Indian Institute of Science, Bangalore); and "Deformation of Composites," N. Balasubramanian (Asbestos Cement, Ltd., Bangalore).

The ICMS-83 proceedings are to be printed under the editorship of the conference convener, V. Ramaswamy. The ONR Far East *Scientific Bulletin* will be publishing detailed reports on the conference and on visits to the Reactor Research Center, Kalpakkam; the Defense Metallurgical Research Laboratory, Hyderabad; the National Aeronautical Laboratory and the Indian Institute of Science, Bangalore; and the Indian Institute of Technology, Madras.

R.W. Armstrong

SCOTTISH CONFERENCES SET FOR SEPTEMBER

Centenary Conference on Marine Safety, 7-9 September 1983, Univ. of Glasgow

Prof. P.A. Frieze (Department of Naval Architecture and Ocean Engineering, The University, Glasgow G12 8QQ, Scotland) has organized the Centenary Conference on Marine Safety to cover offshore and marine safety issues. Sessions are scheduled on Classification and Certification, chaired by J. Cheshire, Lloyd's Register of Shipping; Operational Safety, chaired by J.W. Doerffer, Rector, Technical Univ., Gdansk; Safety of Offshore Structures, chaired by M. Ford, Britoil Limited, Glasgow; and Special Topics in Marine Safety, co-chaired by T.J. Parker, Harland and Wolff, Belfast, and J.F. Denholm, London. Thirty-two papers from the UK, Japan, Norway, Australia, Poland, Canada, Sweden, and the US are scheduled for presentation, including,

for example, "Challenge to Structural Failures in Ships," A. Akita, Nippon Kaiji Kyokai; "Safety of Offshore Platforms--Classification Rules and Lessons Learned," O. Furnes, Det Norske Veritas, Oslo; "Simulation in Marine Activities," C.A. Edmonds, YARD Limited, Glasgow; "Ship Stability and Practical Application of Effective Procedures in Design," C. Kuo, Univ. of Strathclyde; and "Vessels for Arctic Operations," P. Noble, Arctec Canada Limited, Calgary.

Second International Conference on Composite Structures, 14-16 September 1983, Paisley College of Technology

Dr. I.H. Marshall (Department of Mechanical and Production Engineering, Paisley College of Technology, Paisley, Scotland PA1 2BE) is conference director for the Second International Conference on Composite Structures; the first conference was in 1981. The meeting is intended to bring together users, manufacturers, designers, and researchers in the field of composite materials used for structural or engineering applications. The Scottish Development Agency and the National Engineering Laboratory, East Kilbride, are associated sponsors for the international gathering, which includes research papers from the UK, France, India, the US, Kenya, Germany, Japan, Taiwan, Norway, Yugoslavia, Canada, Hungary, and Greece. Plenary papers are "Control of Carbon Fiber Composites by Acoustic Emission," A.R. Bunsell, École Nationale Supérieure des Mines de Paris, and "Biaxial Failure of Glass Fiber Reinforced Plastics--Mechanisms, Modes and Theories," M.J. Owen, Univ. of Nottingham. The following pairs of parallel sessions are planned: Failure Analysis, and Structural Analysis: Structural Systems; Fracture Mechanics, and Structural Monitoring; finally, Research and Development, and Structural Analysis: Analysis of Platework Structures. Additional sessions are Transportation Engineering, Vibration Studies, and Structural Analysis: Buckling Studies.

The conference proceedings will be published by Applied Science Publishers, who have announced recently that they will also publish quarterly the international journal *Composite Structures*, edited by I.H. Marshall. Marshall has issued a call for papers on design, research and development studies, experimental investigations, theoretical analyses, and fabrication techniques relevant to the application of composites in load-bearing components for assemblies or complete composite structures.

R.W. Armstrong

SAFEST TRANSPORTATION IN THE WORLD

Several train systems around the world have remarkable safety records. Super-fast trains like the Japanese Shinkansen "Bullet" and the French "Train Grand Vitesse" operate at speeds around 260 km/hr with almost no accidents. Britain's "125" trains (named for the 125 mph speeds attained on parts of the route) often have more casualties among the track maintenance crew than among the millions of passengers carried every year. In Kobe, Japan, an unmanned train carried 21 million passengers from downtown to Kobe Island in 1981; problems were minor--occasionally a traveler caught his hand or foot in a door, or a vandal kicked out a window.

No transportation system, however, can match the long-term safety record of the overhead monorail "*Schwebebahn*" in Wuppertal, West Germany. The Schwebebahn was first built in 1901, and since then it has carried 1.3 billion passengers without a single passenger fatality or serious operational accident. Historical sources indicate that the Schwebebahn overhead monorail concept arose not as a tourist attraction but as a practical engineering approach to the peculiarities of the Wupper River valley's topography and mass transit needs. The area is hilly and windy and the soil is rocky; the conditions precluded subway construction. In addition, at the turn of the century there were several derailments on New York's conventional elevated rail system. The Germans wanted to prevent such accidents, so they built a monorail, which cannot jump its track.

The Schwebebahn operates today much as it did 80 years ago. Two-car trains hang suspended from an elevated rail structure supported by 472 arched triangular frames (a total of 944 "legs and feet"). Compared with the supports for US elevated systems, the German structure appears to be quite light, and it does not detract from the countryside (Figure 1). The track is 13 km long, and for much of the distance it winds over the Wupper River at an average height of some 40 or 50 feet above the water. There are 17 stations, which are simple raised platforms open at each end. One segment of the route is perhaps unique in mass transit systems; there are several chemical plants along the river, and the piping from the plants often extends across the river, passing both over and under the Schwebebahn trains. The passenger has an unusual sensation of "sailing" through a complex structure of pipes and cables, while swinging gently over the curves of the river.

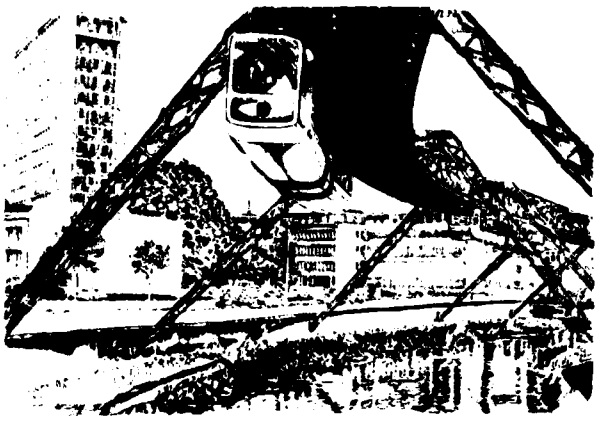


Figure 1. The Schwebebahn.

Four 50-kW motors drive each train. A thyristor gear system, from Siemens and AEG-Telefunken, gives smooth acceleration up to the maximum speed of 60 km/hr. The cars are lightly hung on their greased monorail; a single entering passenger can cause a perceptible swing in the whole train.

Perhaps the Schwebebahn's main technical limitation is that the old steel in the supports has a high sulfur content, which makes welding repairs difficult. Certain parts of the frame are gradually being replaced, and the average radius of the curves is being increased at some points along the route. Total costs are about $6.40 (US) per kilometer to operate and to amortize a train carrying a maximum of 200 passengers.

Obviously the Wuppertal system benefits from its conservative design, its moderate operating speeds, and its many fail-safe provisions. Reportedly, even a "mad engineer" could not crash a train: when two trains are in the same "block," all current is shut off. In 1950, a circus operator rode a baby elephant on the Schwebebahn as a publicity stunt. While the train was moving, the elephant panicked, burst out of the car shell, and plunged headfirst into the river. But the Schwebebahn's safety record remained unblemished; the elephant, which was not seriously injured, was retrieved from the river and appeared in the evening performance.

N.A. Bond

BRITAIN R&D TO EMULATE JAPANESE

The Joint Opto-Electronic Research Scheme (JOERS) is a plan to make Britain competitive in the world opto-electronic market. It is patterned after the research and development programs of the Japanese Ministry of International Trade and Industry. JOERS is a 5-year program bringing together industry, academia, and government. During the period, the UK's Science and Engineering Research Council will provide £5 million to universities, the Ministry of Industry will provide £10 million to industry, and industry itself will contribute £10 million. The results of the "pre-competitive research" will be shared by all participants. The areas of research have now been defined and agreed on. Universities are currently drafting competitive proposals; only the best will be funded.

M.N. Yoder

ONR COSPONSORED CONFERENCES

ONR London can nominate two registration-free participants in the conferences it supports. Readers who are interested in such participation should contact the Chief Scientist, ONR London, as soon as possible.

European Specialist Workshop on Active Microwave Semiconductor Devices, Maidenhead, UK, 4-6 May 1983.

Sixth Workshop on IMS Observations in Northern Europe, Windsor, UK, 16-20 May 1983.

International Symposium on Phase Relationships and Properties in Multicomponent Polymer Systems, Capri, Italy, 30 May - 3 June 1983.

International Conference on Ellipsometry and Other Optical Methods for Surface and Thin Film Analysis, Paris, 7-10 June 1983.

NATO ASI on Physics of Submicron Semiconductor Devices, Pisa, Italy, 10-23 July 1983.

Seventh International Conference on Vacuum Ultraviolet Radiation Physics, Jerusalem, Israel, 8-12 August 1983.

8th European Symposium on Fluorine Chemistry (ESFC-8), Jerusalem, Israel, 21-26 August 1983.

Sixth International Conference on Erosion by Liquid and Solid Impact (ELSI VI), Cambridge, UK, 4-8 September 1983.

International Conference on Electronic Properties of Two-Dimensional Systems, Oxford, UK, 5-9 September 1983.

CONFERENCES (CONT'D)

1983 International Conference on Fourier Transform Spectroscopy, Durham, UK, 5-9 September 1983.

Second International Valencia Meeting on Bayesian Statistics, Valencia, Spain, 6-10 September 1983.

Microcircuit Engineering 83 Conference, Cambridge, UK, 26-29 September 1983.

16th European Conference on Laser Interaction With Matter, Imperial College, London, UK, 26-30 September 1983.

ONRL REPORTS

To request reports, check the boxes on the self-addressed mailer and return it to ONRL.

C-3-83: *The 2nd European Conference on Computer Aided Design in Small- and Medium-Size Industries*, by W.G. Magnuson, Jr. The conference emphasized applications of computer aided design in industries which have limited resources and are forced to innovate in order to compete. Specific topics included computer-aided design and manufacturing (CAD-CAM) user groups, mechanical engineering applications, CAD-CAM investment strategies, basic CAD techniques, CAD-CAM education and training, and applications in architecture and building design.

C-4-83. *The 12th International Quantum Electronics Conference*, by P.D. Drummond. The 12th International Quantum Electronics Conference was held in Munich, Germany, from 20 through 25 June 1982. This report describes presentations on dynamical nonlinearities, quantum optics, bistability, laser spectroscopy, and theory.

R-1-83: *Robot Manipulator Control*, by J.F. Blackburn. This report presents a synthetic approach for calculating the control of robot manipulators. The initial control problem is broken down into linear control and modelling problems. The approach allows derivation of numerous schemes (adaptive or not) of control proposed in the literature and suggests new schemes. It is shown that the problem of modelling is difficult but is less crucial if one can synthesize robust controls that are not sensitive to errors of modelling.

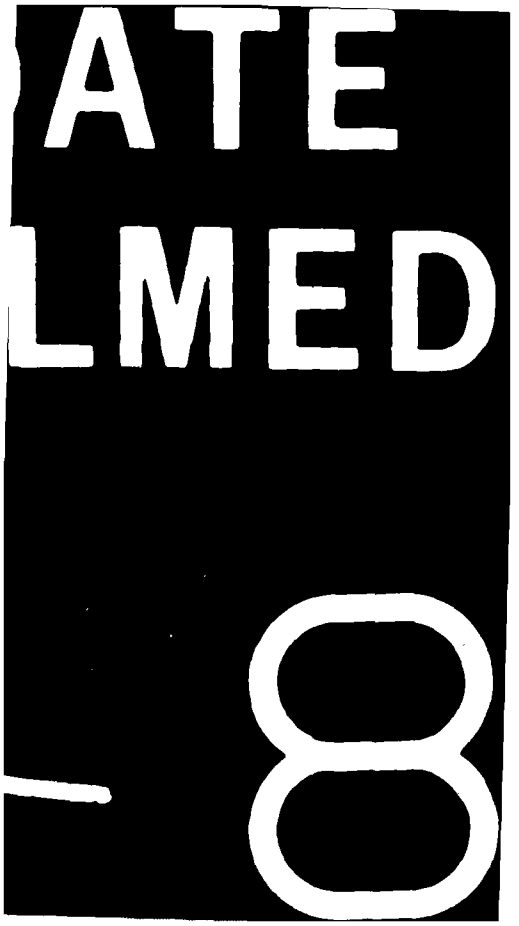
R-2-83: *Statistics, Operations Research, and Management Science in Europe--1982: Summary Report*, by D.R. Barr. This report discusses the state of European research in statistics, operations research, and management science. The report analyzes trends in research and examines conditions that affect work in British and Continental universities.

R-3-83: *Free Electron Laser Research in Europe*, by J.R. Neighbours. This report describes the activity in free electron laser research in France, Israel, Italy, and the United Kingdom. In addition, the report lists key scientists and their recent works.

R-4-83: *Annular Plasmas for Intense X-radiation Sources: Assessment Report*, by D. Mosher. A new technique for annular plasma production developed at the École Polytechnique, Palaiseau, France, appeared to solve many of the source creation problems currently encountered in US Department of Defense programs.

EUROPEAN VISITORS TO THE US SUPPORTED BY ONR LONDON

Visitor	Affiliation	Organization to be Visited
Prof. H.C.A. Dale	Ergonomics Research Group Univ. of Hull 26 Newland Park Hull HU5 2DW	Navy Personnel Research & Development Center, San Diego, CA (27-29 June 1983) Aviation Psychology Lab Ohio State Univ. (4-6 July 1983) Wright-Patterson AFB (4-6 July 1983)
Dr. R.J.A.W. Hosman	Department of Aerospace Engineering Delft Univ. P.O. Box 5058 2600GB Delft The Netherlands	Navy Personnel Research & Development Center, San Diego, CA NASA-AMES Laboratory Sunnyvale, CA (Both May-June 1983)
Dr. R. Huber	*Hochschule der Bundeswehr* München Neubiberg, FRG	CNA, Alexandria, VA NPG School, Monterey, CA (June 1983)
Mr. C.E.C. Wood	General Electric Company, Ltd. Hirst Research Centre East Lane Wembley Middlesex HA9 7PP	NRL, ONR (24-25 May 1983) Cornell Univ. (27 May - 18 June 1983) Univ. of Vermont (20-24 June 1983)


ATE
LMED
8